Lecture Notes Series 26

E-Manual on

Integrated Pest Management in Cashew

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Manual on

INTEGRATED PEST MANAGEMENT IN CASHEW

Lecture Notes Series 26

ICAR-Directorate of Cashew Research
Puttur - 574 202, Dakshina Kannada
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INTEGRATED PEST MANAGEMENT IN CASHEW: AN OVERVIEW

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The pivotal goal of integrated pest management strategy is to use approaches that are effective, practical, economical and environmentally sound. The presence of a pest does not always cause a loss in quality or quantity of an agricultural product. To justify the cost of control, pest populations must be large enough to cause significant damage. Using integrated pest management (IPM) can help farmers to determine if the benefits of pesticides and other pest management tactics exceed the cost of control. If benefits don't exceed costs, time and money are wasted.

IPM is a systematic plan which brings together different pest control tactics into one programme. IPM can be defined as "A comprehensive approach to pest control that uses a combined means to reduce the status of pests to tolerable levels while maintaining a quality environment." In simple, IPM is an ecosystem-based strategy that focuses on long-term prevention of pests or their damage through a combination of techniques such as biological control, habitat manipulation, modification of cultural practices, and use of resistant varieties. In recent past, pest management has shifted from relying heavily on pesticides to using an integrated approach based on pest assessment, decision making and evaluation.

IPM is a way of thinking about pest management that values:

- Using knowledge about the pest's habits, life cycle, needs and dislikes
- Using the least toxic methods first, up to and including pesticides
- Monitoring the pest's activity and adjusting methods over time
- Tolerating harmless pests, and
- Setting a threshold to decide when it's time to act

In general, IPM

- Integrates multiple pest management tactics (chemical, biological, cultural, mechanical).
- Reduces pests to tolerable levels - does not emphasize pest eradication or elimination.
- Incorporates economic sustainability.
- Incorporates environmental and social concerns.

Why IPM is needed?

i) IPM helps to keep a balanced ecosystem

Every ecosystem made up of living things and their non-living environment, has a balance. The actions of one kind of organism in the ecosystem usually affect other species. Introducing chemicals into the ecosystem can change this balance, destroying certain species and allowing other species to dominate. Pesticides can kill beneficial insects that consume pests, leaving few natural mechanisms of pest control.

ii) Ineffectiveness of Pesticides in certain circumstances

Chemicals become ineffective when pests become resistant to them. More than, 600 cases of pests (insects, weeds, pathogens) developing resistance has been documented to date. Furthermore, pests may survive in situations where the chemical does not reach pests, is washed off, is applied at an improper rate, or is applied at an improper life stage of the pest.

iii) IPM can save money

IPM can avoid crop loss caused by pests and prevent unnecessary pesticide expense. Applicators can save on pesticide costs because the need for control, rather than routine application triggered by the calendar, is the basis for applying pesticides.

iv) IPM promotes a healthy environment

Using IPM strategies helps keep adverse effects on the environment to a minimum.

v) IPM maintains a good public image

IPM is now demanded by many sectors of our society. IPM has been implemented to grow our food, to manage turf and ornamentals, to protect home and business structures, to manage school grounds, and to protect humans, pets, and livestock health.

Six Tactics of IPM

The goal of using multiple tactics is to effectively suppress pests below injurious levels and avoiding outbreaks. Many tactics keep pest populations off-balance and avoids development of resistance to pesticides.

i) Cultural methods

Suppress pest problems by minimizing the conditions they need to live (water, shelter, food). Growing crops that are adapted to your growing conditions, planting them in the

right place, giving proper attention to their water and nutritional needs and the like. Strong plants resist diseases, outgrow weeds and are less likely to succumb to insects.

ii) Physical methods

Prevent pest access to the host or area, or, if the pests are already present, physically removing them by some means. For example, this could mean using barriers, traps, vacuuming, mowing or tillage, depending upon the pest and situation.

iii) Genetic methods

Use pest-resistant plant varieties developed by classical plant breeding. Recently, this category has been expanded to include genetically engineered pest resistance, such as Bt corn or potatoes. There are also special uses of genetic techniques on pests themselves, such a "sterile male" insect releases.

iv) Biological methods

Use predators, parasites and diseases of pests in a targeted way to suppress pest populations. Use of microbial diseases of pests have become part of the chemical pesticide registration process and is treated below under Chemical methods.

v) Chemical methods

There are many "chemicals" that are used in pest management situations, but not all chemicals are alike from the standpoint of their range of action, toxicity, or persistence in the environment. There will be more information on the classes of chemicals in the Learning to Use Tactics section, Activity Lessons from Labels.

vi) Biorational methods

Biorational chemicals are those that are less universally toxic and target a specific aspect of pest biology. An example might be diatomaceous earth used to scratch the surface of insects to dehydrate them, or microbial pesticides that affect only a specific group of insects. There are some biorational chemical tactics that are hard to classify by toxicity or that are used together in innovative ways with other tactics. An example of this would be insect pheromones used together with sticky traps. Pheromones are the chemicals produced by insects to attract their mates, and so these substances are not toxic. But they can be used in large amounts to "confuse" the mating process or to attract insects to a trap. Other examples of such chemicals are repellants, attractants, and antifeeding agents.

IPM in cashew:

Cashew (*Anacardium occidentale* L.) is an important commercial tree nut crop. Pest infestation is a serious constraint in cashew production in almost all cashew growing regions. Cashew is infested by large number of pests including sucking pests, defoliators, borers, thrips, mites etc. Among the multitude of pests infesting cashew, tea mosquito bug (TMB) and cashew stem and root borer (CSRB) are most common and key insect pests in Indian subcontinent. At present to manage cashew pests, chemical treatments are being followed widely. However, there is a scope for biological and behavioural management of pests in future. In cashew, the research efforts made on various pest management tactics are briefed here.

Tea mosquito bug:

Tea mosquito bug is a sucking pest belonging to genus Helopeltis under order Hemiptera. *Helopeltis* has palaeotropical distribution extending from West Africa to New Guinea and northern Australia. There are around 41 species of TMB (*Helopeltis* spp.) recorded in the world and three species namely, *H. antonii, H. bradyi* and *H. theivora* are confined to India. *H. antonii* is only confined to south and east India, Andaman Islands and Sri Lanka whereas, *H. bradyi* is confined to south India, Sri Lanka and Indonesia and Malaysia and *H. theivora* in south India, north east India, Sri Lanka and southeast Asia. Among the three species of *Helopeltis H. antonii* is the dominant species infesting cashew throughout India. The population of TMB reaches its peak during the flushing, flowering and fruiting season in cashew *i.e.* from November to February. Both nymphs and adults suck sap from tender shoots and leaves, floral branches, developing nuts and apples by making a number of feeding lesions that develop into necrosis. During outbreak situation, the entire flush dries up and the trees exhibit a scorched appearance. On an average, TMB infestation results in 30 per cent yield loss, but it has got potential to cause cent percent loss in certain circumstances. Apart from cashew, TMB also occurs on mango, jamun, ornamental Acalypha, neem, moringa, cotton, henna, guava etc.

IPM of tea mosquito bug

- Since this pest is a low density pest, timely management is essential. Around 10 % of damaged fresh flushes may be considered as the ETL for TMB.

- All the released varieties are susceptible for TMB attack and there is no evidence on the existence of a completely tolerant / resistant cashew type against TMB infestation. But the continuous field screening of common varieties at DCR revealed that Dhana, Bhaskara and the accession VTH 153/1 had comparatively less TMB infestation.

- Like any other pest, TMB also has its own natural enemies. Among the parasitoids, *Erythmelus helopeltidis* Gahan., *Telenomus* cuspis (Scelionidae), *Chaetostricha* sp. and *Gonatocerus* sp. nr. bialbifuniculatus are the egg parasitoids present in West Coast regions, while, *Ufens* sp. is found in East Coast regions (Vridhachalam). The build-up of this pest is naturally regulated through these egg parasitoids to some extent. But none of these parasitoids are amenable for mass culturing.

- Among the predators, ants like *Crematogaster wroughtonii* Forel and *Oecophylla smaragdina* F. (Formicidae) predate on TMB. In Australia, red ants are properly maintained in cashew orchards to manage cashew pests. In India also, especially in Kerala, red ants are found effective in managing pests of cashew. Several species of spiders, reduviid bugs and praying mantids have also been recorded as predators of the TMB. Though culturing of reduviids and praying mantids is possible in lab conditions, their field efficacy in managing TMB needs investigation. There are also entomopathogens like *Aspergillus flavus*, *A. tamarii* and *Beauveria bassiana* that cause mycosis in *H. antonii*.

- With the increasing awareness on eco-friendly approaches, it is essential to explore the opportunities of pest management by behavioural means. Presence of sex pheromone activity in female TMB is confirmed in studies conducted at DCR, wherein mated as well as unmated female TMB tend to attract more males throughout its life time. If research is successful in isolating the pheromone chemical and synthesizing it, it will be possible to use female sex pheromone blend to attract males under field condition in future.

- The insecticides tested against TMB showed that sprays of monocrotophos, λ-cyhalothrin, carbaryl, Acetamiprid, Imidacloprid, triazophos etc recorded the least per cent TMB damage. In the endemic areas, it is appropriate to spray three times with any of these insecticides during most vulnerable periods of crop coinciding with flushing, flowering and fruiting stages. Although, cashew is an insect pollinated crop, spraying of these insecticides during flowering season does not influence much on the fruit set.

- A strong surveillance programme and proper monitoring of the pest- situation has become imperative to manage this pest. Integrated Pest Management involving specific variety, monitoring, surveillance, conservation of natural enemies and adopting judicial spraying of insecticides is a good package to manage TMB. Mid season/late season flowering cashew varieties such as Bhaskara, are able to escape from the severity of the pest to a certain extent.

- Even though, all groups of insecticides and plant products (botanicals) were evaluated against this pest, none of them exhibited any ovicidal action. However, λ-cyhalothrin (0.003%) and carbaryl (0.1%) had shown longest residual action against nymphs and adults thus delaying the frequency of sprays.

- Need based sprays are recommended during most vulnerable periods of crops such as flushing, flowering and fruiting stage of the crop. As the insect dispersion in field is clumped in localized pockets rather than random, the blanket spraying is unwarranted. Hence, tree-to-tree spraying, sparing the red ant nested ones can be advocated.

Cashew stem and root borer (CSRB)

Besides TMB, widespread incidence of cashew stem and root borers (CSRB) is another impediment in cashew cultivation. There are two species of CSRB (*Plocaederus ferrugineus* L and *P. obesus* G.) (Coleoptera: Cerambycidae). Among which *P. ferrugineus* is the primary species, infesting cashew in all parts of India and *Batocera rufomaculata* DeG. also occurs in association with *P. ferrugineus.*

Eggs are laid in the crevices of the bark or soil surrounding the roots. Hatching grubs start damaging the bark and bore within. The larval (grub) stage is the damaging stage of the pest. Upon full development, grubs turn into pupa and emerge as beetles. The egg period lasts for 4-8 days. Grub period comprising of 7-10 instars lasts even up to 10 months. The symptoms of damage include extrusion of frass, occurrence of gummosis, pre-mature yellowing and shedding of leaves, drying of twigs and finally death of the tree. These hidden pests remain as an impediment in maintaining the optimum tree population in all cashew growing tracts of India. The severe incidence of CSRB has been documented from Sri Lanka and Tanzania and China. Occurrence of CSRB in varying levels has been reported from various other countries such as, Bangladesh, Burma, Hawaii, Hong Kong, India, Sri Lanka, Taiwan, Thailand and Vietnam. A laboratory rearing technique of CSRB has been standardized at DCR, Puttur.

IPM of CRSB

- Controlling this pest is a tough job, as the borer remains in a concealed condition in the interface of bark and hard wood, and normally it escapes from the attack of the natural enemies. Integrated Pest Management approaches include surveillance, identifying the infested trees by the damage symptoms, collection of grubs by careful removal of the bark or killing the grubs/pupa by inserting a metal wire and swabbing the affected portion with chlorpyriphos (0.2%). Swabbing of neem oil also protects the trees to some extent.

- Application of coal tar: kerosene @ 1:2 was recorded to protect the trees for a period of months. But the commercial neem products such as neem oil, Limalool, Nimbecidine, Godrej Achook and RD- Repellin at 0.5 % as a prophylactic measure could not protect the trees consistently. Young trees could recover from CRSB infestation upon drenching of insecticides such as monocrotophos, fenthion, chlorpyriphos, fenitrothion and carbaryl+sevidol at high doses. Root feeding of monocrotophos led to partial translocation and only those trees in early stages of infestation showed recovery.

- Swabbing the pest infested portion after removal and drenching the root zone with chlorpyriphos (0.2%) as post extraction prophylaxis (PEP) was found effective in reducing reinfestation up to 70.7 per cent. It is to be remembered that large population of CSRB grubs thrives in dead cashew trees as well as CSRB infested trees. The trees having more than 50 per cent of bark circumference damaged/ having yellow canopy are considered as trees beyond recovery. Hence, it is essential to adopt phytosanitation by removing the dead trees and trees beyond recovery by uprooting during monsoon season *i.e.,* prior to emergence of adult beetles and dispose off suitably without delay to reduce build-up of pest inoculum in a given locality.

- Fumigants like EDB, Aluminium phosphide, chloroform were tried at different doses by application into the tunnels of stem borer grubs. Though high mortality of grubs was recorded with chloroform, high cost of treatment and its potential hazards do not permit its recommendation.

- Mycopathogens like *Metarhizium anisopliae* and *Beauveria bassiana* could cause mycosis of CSRB grubs under field survey. It was recorded that the spores of *M. anisopliae* survive for three months under field condition. Mixing the spawn with organic matter like FYM, neem cake and cashew apple can enhance the spore load

under the field condition. Studies conducted in Madakkathara of Kerala showed persistence of *B. bassiana* and *M. anisolpliae* in soil, soil+FYM, soil+neem cake indicated survival of fungi up to 180 days inducing 51-71 % grub mortality.

- Entomopathogenic nematodes like *Steinernema bicornutum*, *S. abbasi* and *Heterorhabditis indica* are capable of causing mortality of CSRB grubs within 5-15 days under lab conditions. Studies conducted at DCR revealed that *S. bicornutum* had longest survival up to 150 days in soil indicating its potential as a biological control agent for management of CSRB and can be an efficient IPM component. Hence, investigations are required towards field application of nematodes in CSRB management.
- It was observed that the bark of infested tree and fresh frass are found to elicit response from virgin and mated female beetles under olfactometer trails. Hence, possibility of development of kairomone based CSRB management needs to be explored.

Apart from these two pests, there are also other pests infest cashew. Some are regional specific and season bound. Management actions taken against TMB manage most of these pests too. But it is essential to record the activities of flower thrips and flower feeding caterpillars as well as the yield loss caused by them, so as to devise suitable management plans. Though chemical management is followed widely to manage cashew pests, cashew kernels obtained from those treated trees are found free from insecticide residues.

Disease management

In India, very less information is available on occurrence of diseases in cashew and their management. However, a large number of diseases are associated with cashew starting from seedling to old trees. Among the diseases, the inflorescence blight/ die back disease is serious that occurs due to severe infestation by tea mosquito bug, and is more pronounced under cloudy weather. Proper diagnosis of diseases, understanding the epidemiology and taking up suitable management measures are required to protect the trees from diseases. Some diseases of cashew are given in table 1.

Disease	Scientific name
➢ Nursery stage	
• Damping-off	*Phytopthora palmivora* Butler
• Seedling Blight	*Cylindrocladium scoparium*
• Root-rot disease	*Pythium ultimum* Tron
➢ Inflorescence	
• Anthracnosis	*Colletotrichum gloesporioides*
• Inflorescence Blight	*Gloeosporium mangiferae & Phomopsis anacardii*
➢ Leaves	
• Anthracnosis	*Phytophthora nicotinae & Asterina carbonacea*
• Diplodia rot	*Diplodium anacardiacearim*
• Leaf blight	*Pestalotia paeoniae*
➢ Nut diseases	*Aspergillus tamari, Penicillium citrium, Lasiodiplodia theobromae, Gloeosporium spp.*
➢ Others	
• Dieback	*Pellicularia salmonicolor*
• Gummosis	*Diplodia natalensis*
• Powdery mildew	*Odium spp.*

TEA MOSQUITO BUG AND ITS MANAGEMENT

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Introduction

Tea Mosquito Bug (TMB) *Helopeltis* spp. (Hemiptera: miridae) is one of the major pests of cashew affecting its tender shoots, panicles, nuts and apples. Both nymphs and adults feed by sucking the plant parts, injecting polyphenol oxydase (salivary enzymes). Typical feeding damage by *Helopeltis* spp. appears as a discoloured necrotic area or a lesion around the point of entry of the mouth parts in the plant tissue. The infestation of inflorescence results in "blossom blight". Four species of TMB, *Helopeltis antonii* Signoret, *Helopeltis bradyi* Waterhouse, *Helopeltis theivora* Waterhouse and Pachypeltis maesarum Kirkaldy are found in India. Among them, *H. antonii* is the dominant species. Each insect can damage up to 3 or 4 shoots or panicles leading to heavy loss in yield. Under outbreak situations, a damage of 25-30 per cent and even 100 % may be expected.

Biology

The adult bugs are slender, elongate, 6 to 8 mm long, reddish brown in colour with a black head, red thorax and black and white abdomen. Colour variation among the adults has been reported. A pin like, knobbed scutellar process occurs dorsally in both the nymphs and adults except in the first instar nymphs.

The pre-oviposition and oviposition periods ranged from 3 to 5 days and 5 to 10 days, respectively. More than 75 per cent of the eggs are deposited during the first half of oviposition period. The presence of sex pheromone in females of TMB has been demonstrated. The eggs are inserted into tender shoots; stalk of inflorescence and on the leaf midrib and petioles, either singly or in groups of 2 to 6. Presence of a pair of minute silvery hair like unequal chorionic processes indicates the presence of an egg. The five nymphal instars are completed in 8 to 13 days. Adults live for about 5 to 18 days and the total life cycle is 20 days. A mass culture technique for TMB has been standardised using cashew shoot as a host material.

Host range

The nymphs and adults of TMB feed on a wide variety of crop plants such as eucalyptus, mahogany, neem, cocoa, cinchona, guava, drumstick, black pepper, Singapore cherry, cotton, *Lawsonia inermis* (mehendi) and allspice. During off season, the activity is mainly confined to these hosts and some weed plants like *Chromolaena odorata*, *Macaranga peltata*, *Melastoma malabathricum*, *Calycopteris floribunda* etc and the pest migrates to cashew during flushing, flowering and fruiting period of cashew. But, cashew is the most preferred host for TMB during the cropping season.

Distribution

The pest is distributed in most of the cashew growing regions of our country including Kerala, Karnataka, Goa, Maharashtra, Tamil Nadu, Andhra Pradesh, Gujarat, Chhattisgarh and Orissa. The pest is severe in West coast regions compared to East coast regions. Neem is the primary host of *H. antonii* especially in Tamil Nadu and southern parts of Karnataka and Andhra Pradesh. The pest spreads to cashew from neem in these areas, whereas in Maharashtra, Gujarat and Chhattisgarh it is confined mainly to cashew. Apart from *H.antonii, H. theivora*, *H.bradyi*, and *P. mesarum* are also causing similar damage to cashew in certain areas.

Nature of damage

Both nymphs and adults suck the sap from tender leaves, shoots, panicles and immature nuts and apples. The injury due to insertion of stylets by the insect induces exudation of resinous gummy substance. TMB also releases certain toxic secretion into cashew. All these activities of the insect lead to the typical formation of necrotic lesion symptoms around the point of stylet insertion by the bug. The lesions on shoots coalesce and ultimately result in drying of shoots/ shoot blight.

The infestation of inflorescence or panicles results in blossom blight. In certain endemic areas, most of the flushes dry up and the tree presents a scorched appearance. The immature nuts infested by TMB shrivel and dry up, while older nuts and apples develop a scabby appearance. Each insect can damage 3-4 shoots or panicles during its life cycle thereby, leading to heavy loss in nut yield.

Seasonal abundance

The build-up of the pest commences during October - November synchronizing with the emergence of new flushes, after the cessation of the South-West monsoon. In general, the activity is minimum during the monsoon period (June - September). The population reaches a peak during January, when the trees are in full bloom. However, the activity of this pest is seen till May in cashew. In young plantations, the pest is noticed continuously with a higher intensity during February and March.

Reactions of cashew types

Though all the germplasm accessions and related varieties are potentially susceptible to this pest, “Bhaskara”, a variety developed at Directorate of Cashew Research, Puttur escapes TMB damage due to non-overlapping of the cropping period with that of peak pest population. This variety was developed from a tree of seedling origin identified during 1982 from severely of TMB infested location, situated at Forest Department Cashew Plantation, Gaodengrem, Canacona Taluk, South Goa. This variety has midseason flowering habit which aids in escaping from the attack of TMB under low to moderate outbreak situation. In case of pest damage on first batch of panicles due to TMB, subsequently the trees of this variety flower again enhancing the possibility good yield during the same season.

Association of TMB with incidence of disease

The fungal pathogens, *viz*., *Gloeosporium mangiferae* and *Phomopsis anacardii* have been reported to cause blossom blight in association with TMB. The feeding injury by the bug is one of pre-disposing factors for the infection and expression of die-back disease caused by *Colletotrichum gloeosporoides* and *Botryodiplodia theobromae*. When the dried shoot is split open, discolouration may be seen in softwood region indicating the manifestation of the fungal disease. A loss of 25 to 50 per cent nut in nut in yield has been reported from Karnataka, Maharashtra, Goa, Kerala and West Bengal due to combined effect of TMB and disease incidence.

Natural enemies

A total of four endo- parasitoids have been recorded parasitizing eggs of TMB in West coast regions of the country. They are *Erythmelus helopeltidis* Gahan. (Mymaridae) *Telenomus* cuspis Rajmohana and Srikumar (Scelionidae), *Chaetostricha* sp. (Trichogrammatidae) and *Gonatocerus* sp. nr. *bialbifuniculatus* Subba Rao. In the East coast, *Ufens* sp. is the only parasitoid observed on TMB eggs. However, the attempts to multiply these endo-parasitoids under laboratory conditions were not successful, as these require large number of live TMB eggs alone for the development.

Around 120 species of spiders have been recorded in cashew plantations. The species like *Hyllus* sp., *Telemonia dimidiate*, *Oxyopes swetha*, *Phidippus* sp. and *Matidia* sp. have been observed predating on TMB. Besides, 17 species of reduviid bugs (including *Sycanus collaris* (Fab), *Sycanus galbanus*, *Sphedanolestes signatus* Dist., *Endochus inornatus* Stal., *Irantha armipes* Stal*., Panthous bimaculatus* and *Occamus typicus* Dist. have also been recorded as predators of TMB. Ants of the species *Crematogaster wroughtonii* Forel (Formicidae) and *Oecophylla smaragadina* Fabricius predate on nymphs of the pest. IN addition, there are praying mantids, pentatomid bugs and other predatory insects that predate on TMB in cashew. Similarly, *Aspergillus flavus* and *A. tamarii* are reported as entomopathogens on TMB. Specific strains of *Beauveria bassiana* is also found causing mortality of TMB in certain months.

Botanical control

A few plant products have been tested for their insecticidal activities against TMB. The water emulsions of pongamia oil (3%) was found to cause high mortality of TMB up to 7 days after spraying followed by Neem oil (3 %). Besides, neem seed extract was also found to cause mortality of TMB but at less than 50 % level. Similarly, seed extracts of *Annona reticulata* and *A. squamosa* were found to cause less than 50 % mortality of TMB, but not *Strychnos nuxvomica*. In another experiment, 5 % leaf extracts of *A. reticulata, Tephrosia vogelii* and *S. nuxvomica, Butea frondosa, Adathoda vasica* were found not effective against TMB. The commercial neem pesticides like Nimbecidine, Gogrej Achook, Limanool and RD-9 Repellin at 1 % were not effective in causing mortality of TMB, but have noticeable ovipositional deterrency effect similar to Pongamia oil and neem oil.

Chemical control

Proper surveillance for pest damage symptoms during flushing, flowering and fruiting period is essential for the management of this pest. Whenever the incidence of pest is noticed on 5-10 per cent of the flushes, the first round of pesticidal spray should be given. The second round of spray should be invariably completed within 3-4 weeks time if the TMB population still persists. If panicle damage is severe (beyond 50%) because of delayed insecticidal application, further sprays will not result in improved yields. Hence, it is absolutely necessary to keep a constant vigil on the build-up of the pest especially during first month of flushing and to initiate timely insecticidal control. However, a two spray schedule (need based) is being presently recommended instead of routine/earlier recommended three spray schedule. The third spray needs to be taken up only based on necessity i.e., in case pest population persists even after the second spray.

The present recommendation for chemical management of tea mosquito bug is as follows:

- First spray : Monocrotophos (0.05% *i.e*., 1.5 ml/lit), Imidacloprid (0.6 ml/lit, Acetamiprid (0.5 g/lit), λ-cyhalothrin (0.003% i.e., 0.6 ml/lit), Profenophos (0.05% i.e., 1.5 ml/lit) - at flushing stage
- Second spray : λ-cyhalothrin (0.003%) or triazophos (0.05% i.e., 1 ml/lit) - at flowering stage.
- Third spray (if pest persists) : λ-cyhalothrin (0.003%), profenophos (0.05 5 i.e., 1.5 ml/lit) - at fruit set stage

Though cashew is an insect pollinated crop, use of λ-cyhalothrin (0.003%) during the flowering stage did not affect the fruit set. Among the different insecticides, λ-cyhalothrin (0.003%) has higher benefit cost ratio (4.5). Whenever die- back disease is noticed, the affected shoots and branches below the site of infection should be pruned and destroyed. The cut surface should be protected with Bordeaux paste (10%). Spraying the canopy with Bordeaux mixture (1%) may be followed after this process.

Spraying should be done in the early hours of the day (7-11 AM) or in the evening (3-6 PM). Spraying should be taken up immediately when initial symptoms of TMB damage are noticed. If it rains immediately after spraying, the spraying has to be repeated and entire canopy area should be sprayed. Approximately, 6-8 litres of solution is required for a tree of 15 -20 years depending upon the canopy. It is better to alternate equally effective insecticide for each spray. Empty chemical container should be destroyed by puncturing / cutting into pieces and buried into the soil. Drinking water source should not be contaminated while spraying. Cloth mask covering nose and mouth should be invariably used by the person who attends to spraying.

MANAGEMENT OF CASHEW STEM AND ROOT BORER – A MAJOR PEST OF CASHEW

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Cashew farmers experience several hardships in cashew cultivation due to variation in climate, rainfall and also due to severe insect pest incidence which finally leads to significant loss in nut yield. In cashew, several insect pests attack during various stages of the crop and result in moderate to heavy loss of the crop yield depending on level of insect pest population. Out of these pests, two are major insect pests cause considerable yield loss in most of the cashew growing regions of our country. These are a) Tea Mosquito Bug (TMB) scientifically known as *Helopeltis antonii* and b) Cashew Stem and Root Borers (CSRB) scientifically known as *Plocaederus ferrugineus* and *Plocaederus obseus*.

The adults and nymphs of TMB suck plant sap and lead to drying up of shoots and flower panicles, leading to considerable loss during that cropping season. However, incidence or absence of the pest varies over the years. The other pest, cashew stem and root borers infest the vital bark portion of yielding cashew trees and lead to gradual death of such infested cashew trees. The pest population of CSRB increases over the years resulting in constant loss of tree population. Thus, productivity in a given location gets reduced over the years.

In this brochure, the symptoms of infestation and various approaches to be adopted for managing this pest is mentioned for the benefit of the cashew farmers of the country.

What is cashew stem and root borer?

The insect is normally noticed by cashew farmers at larval stage which feeds on the bark portions of the stem and roots, by making irregular tunnels which enlarge as the larva grows in size. The farmers can notice larvae, pupae and unemerged immature adults in the damaged portions of infested trees. The adult insects belong to the “beetle” group of insects which have hard and stout body and are strong fliers. The adult beetles of this group have long antennae and are active during the night. Hence, these adult beetles are normally not noticed in the cashew plantations during day time.

What are the symptoms of pest damage?

At the base of the CSRB infested tree, gum and fibrous material are exuded in small quantities in the initial stage of attack. During later stages of attack, the infested tree canopies show a sickly appearance and the green leaves turn yellowish and start dropping prematurely. In the severe stages of attack, the twigs dry off and the bark on the trunk starts splitting. At this stage, large quantity of chewed fibers and gum (commonly known as frass) are seen as big lumps at the base of the CSRB infested tree.

When does the pest incidence occur?

Normally the pest incidence is noticed during the months of Dec. to May in different cashew growing tracts of the country. Different stages of infestation are generally seen all round the year. However, certain stages of the pest are noticed in certain months only. During the onset of rainy season the healthy trees turn dark green, whereas, the infested trees remain yellowish, which is a sure indicator of the pest attack in those trees. During the nut collection period, close observation of the tree bases reveals the initial infestation symptoms which can be treated suitably prior to onset of monsoon.

How does the pest damage the cashew trees?

The adult female beetles lay eggs (which resemble rice grains) inside the crevices of the bark of stem or exposed roots. Young grubs hatch from these eggs in 5 – 7 days and immediately start boring into the bark. The grubs feed voraciously for a period of 6 to 8 months and grow rapidly in size and fill the tunnels with chewed fibre and excreta. Their zigzag feeding interferes with movement of water and nutrients in the tree trunk and root zone leading to premature leaf fall, drying of branches and gradual death of the tree. Full grown larvae make tunnels in the heart wood and form a hard cocoon made of calcium secretions. The pupae stay inside these cocoons for 60 – 90 days and adult beetles emerge from such cocoons and continue the life cycle.

What are the insecticides which can manage the pest?

Several insecticides have been evaluated at various research centers, for over a decade. Some of the insecticides have been recently banned / being withdrawn and hence, alternate effective insecticides were evaluated later on. It is to be noted that any insecticidal treatment without removing the pest stages will not be effective.

The pest stages of CSRB in the infested cashew trees (both in the stem region and in the root zone also) have to be carefully removed by skillful chiseling of the tunnels in the infested portion and destroyed. The larvae will be present on the fresh fiber portion of the tunnels both in the stem and in the roots. The fresh fiber in the tunnels can be traced by their light color while, older fibers will be darker. In case the larvae have entered into the heartwood for pupation, they can be killed by inserting a gear wire / any other bending metal wire and poking into the tunnel till a slushy sound is heard or white fluid flows out. After removing or destroying the larvae and other pest stages, the chiseled portion should be swabbed thoroughly with chlorpyriphos (0.2%) solution and the same needs to be drenched onto the soil near the root zone. This has been proven to minimize the re-infestation by the pest.

Repetition of the treatment should be done, if fresh pest infestation symptoms occur after 30-45 days. Another point to be borne in mind is not to damage more than 50 per cent of the bark circumference, as this will lead to girdling and death of the treated tree. In case, more than 50 per cent of the bark circumference has been damaged or the leaf canopy has yellowed, such trees should not be treated, as they do not recover. These trees need to be uprooted and pest stages in those trees should be destroyed. The timber of such uprooted trees should be shifted out of the plantation and can be used as firewood.

How do we prevent the spread of pest infestation?

Two aspects are to be borne in mind to prevent spread of pest infestation;

i) reduction of pest population in a given location and
ii) rescuing the trees in initial stages of infestation.

To achieve these aspects, the CSRB infested trees should be identified in the initial stages of infestation during the nut collection period and marked suitably. Treatment of all such initially infested trees should be done AT A TIME and if possible on a community basis following the method mentioned above. Also, the trees which have yellowing of the canopy and / or have more than 50 per cent of the bark circumference damaged should be uprooted and pest stages in the root zone should be destroyed. This approach is called "PHYTOSANITATION" which helps to reduce the pest population in a given location and leads to lesser fresh incidence of the pest in the subsequent years. Extensive field trials have shown that on adopting this phytosanitary measure, a reduction in the number of freshly infested trees and also a significant reduction in the number of larvae occurring per infested tree could be achieved.

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MANAGEMENT OF MINOR PESTS IN CASHEW

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In India, cashew is reported to be infested by more than 200 pests at different growth and development stages. Insects are extremely diverse and important in any ecosystem. Cashew plantations in general resemble "a single species forest", providing a relatively stable microclimate and food resources for various insect communities. All parts of the cashew plant *viz*., leaf, stem, bark, root, flower, apple and nut are fed upon by at least one pest species, resulting in 11 - 55 per cent loss in yield, if left unchecked. Apart from TMB and CRSB, there are also few other pests that cause considerable damage and yield loss. Some pests may not be problematic in certain regions, but could be a problem in other regions. However, depending on the climate, location and age of the plantation, each geographic region has its own distinctive pest complex. In general, management actions taken for managing TMB could manage these pests also, but separate spraying may be required during certain periods to prevent economic loss. The details of important minor insect pests of cashew are given below.

a) Shoot tip caterpillars *Anarsia epotias* M. and *Hypotima* (*Chelaria*) *haligramma* M. (Lepidoptera: Gelechiidae).

This pest is presently distributed in Goa, Karnataka, Kerala, Tamil Nadu, Andhra Pradesh and Odisha. It occurs on the post monsoon flushes during September-December. Young caterpillars of *A. epotias* are pale yellowish green with black head and turn pinkish-brown later. While, larvae of *H. haligramma* are tiny and yellowish to greenish brown in colour. The egg, larval and pupal period of *H. haligramma* last for 3-4 days, 12-16 days and 7-10 days respectively, and the life cycle is completed within 25-29 days. Larvae of *A. epotias* at the early stage web together the tender leaves and feed within. Later on, they bore in to the terminal shoots and tunnel inside up to 2-3 cm. A gummy substance oozes out from the infected tips and finally the attacked shoots dry up. Larvae of *H. haligramma* also damage shoot tips by folding the fresh leaves and feed within and can tunnel up to 2 cm. The larvae may also damage inflorescences subsequently. Exudation of gummy web like substances mixed with faecal pellets from the injury site can be noticed. Later, the terminal shoots turn black and perish, which results in production of auxiliary shoots.

Management measures:

Spraying may not be required, since, natural enemies including parasitoids take care of this pest. Four larval parasitoids, *viz*., *Pristomerus* sp. (Ichneumonidae), *Apanteles* sp. (Braconidae), *Elasmus* sp. (Elasmidae) and *Sympiesis* sp., (Eulophidae) have been recorded on shoot tip caterpillar larvae causing parasitism up to 25 %. But, under severe incidence, spraying of either quinolphos (2 ml/lit) or phosphamidon (2 ml/lit) or profenophos (1.5 ml/lit) will manage this pest effectively.

b) Leaf miner *Acrocercops syngramma* M. (Lepidoptera: Gracillariidae)

This is one of the important pests of cashew during post monsoon period all over the country. The mining injury by caterpillars occurs both in the tender leaves as well as tender shoots and young plants are more prone to attack. Caterpillars mine and feed below the epidermal layer of the tender leaves causing extensive leaf blisters which later dry up causing distortion, browning and curling of the leaves. As the attacked leaf ages, the holes develop due to drying out of the damaged portion. Generally 1-6 caterpillars damage a leaf. During the developmental period they are dull white in colour and turn pinkish before pupation. After full development, larvae fall off to the soil where they pupate and emerge after 7-9 days as a silvery grey moth. The pest also occurs on Mango and jamun.

Management measures:

Two larval parasitoids *viz*., *Chelonus* sp. and *Sympiesis* sp. have been recorded on leaf miners in Kerala and Goa. Recently, three larval parasitoids namely, *Chyrsocharis* sp., *Aprostocetus* sp. and *Closterocerus* sp. (Eulophidae) are recorded in Puttur region of Karnataka. Spraying may not be required since these larval parasitoids manage this pest even up to 50 %. But under severe incidence in nursery and young plants, spraying is required. Spraying of quinolphos (1.5 ml/lit) or monocrotophos (1.5 ml/lit) or profenophos (1.5 ml/lit) can effectively manage leaf miners.

c) Leaf thrips and flower thirps

Thrips are minute worm like insects damage the crop by sucking the plant sap. Thrips occur throughout cashew growing regions. Leaf thrips occur during October – December and the flower thrips during January – April. If leaf thrips attack at nursery stage, even death of seedlings may occur. Among the leaf thrips, *Selenothrips rubrocinctus* is very serious in nursery and young cashew plantations. Initially it attacks lower leaves and cause premature leaf fall, stunting and finally drying of seedlings. In grown up plants, it damages young leaves, shoots, inflorescence and flowers and is more active during summer months. Among the flower thrips, *Scirtothrips dorsalis* and *Rhynchothrips raoensis* are prevalent in the East coast regions of India, whereas in West coast regions, *Haplorthrips ceylonicus* and *Frankliniella schultzei* are prevalent. Flower thrips attack buds, flowers, immature apples and nuts. Thrips infestation causes shedding of flowers, immature fruit drop, formation of scabby as well as, malformed apples and nuts. Up to 15-25 per cent fruit drop is noticed due to thrips damage.

Management measures:

There are several predators like various syrphids (eg., *Paragus* sp.), coccinellids (*Pseudospidemerus circumflexa* Mots., *Menochilus sexmaculata, Coccinella transversalis, Scymnus* sp*., Illeis cincta*), lace wing bugs etc take care of this pest. Spraying of monocrotophos (1.5 ml/lit) or lambda-cyhalothrin (0.6 ml/lit) or dimethoate (2 ml/lit) or quinolphos (2 ml/lit) or carbaryl (1 g/lit) is effective for managing thrips.

d) Leaf beetles and weevils: *Monolepta longitarsus* Jac., *Neculla pollinaria* Baly (Chrysomelidae: Coleoptera), *Deporaus marginatus* (Coleoptera: Attelabidae).

Several chrysomelid beetles attack cashew mostly during post monsoon flushing period. Among them, *M. longitarsus* and *N. pollinaria* are important defoliators. While, *D. marginatus* occur occasionally on tender shoots and nursery plants. Adult beetles of *M. longitarsus* are small, shiny red, also occur in four different colour morphs in elytra. While, adults of *N. pollinaria* are white or ash coloured, turn into black or grey upon aging. Since all other stages of these chrysomelid beetles remain inside the soil, only adult beetles are seen on cashew shoots. The adults of *D. marginatus* are small blackish weevils with orange red thorax.

Monolepta beetles appear abundantly especially on young trees and skeletonise the leaves which gradually dry up. Tender shoots are also attacked that finally dry off. When nursery seedlings are attacked, the entire seedlings dry up. In old trees, a group of 60-75 beetles are capable of causing complete drying of tender shoots in 2-3 days. It is also severe on current season limb pruned trees. While, adults of *N. pollinaria* also attack the post harvest flushes causing defoliation and drying up of the shoots. Scrapping of the bark of tender shoots by the beetles appears as linear depressions. *D. marginatus* weevils remain on the underside of the leaves and scrape the leaf surface making minute feeding holes which appear as 'windowpanes' on young leaves.

Management measures:

Spraying of any systemic or contact insecticide takes care of these pests. Spraying of fenitrothion (1ml/lit) or chlorpyriphos (1.5 ml/lit) or monocrotophos (1.5 ml/lit) or quinolphos (2 ml/lit) or lambda- cyhalothrin (0.6 ml/lit) could cause mortality of the beetles in a short period.

e. Leaf folders and leaf rollers: *Hypatima haligramma* M. (Gelechiidae), *Caloptilia tiselaea* M. (Gracillaridae), *Dudua aprobola* M. (Tortricidae), *Sylepta derogatta* F. and *Sylepta auranticollis* (Pyralidae), *Anigraea albomaculata.*

Larvae of *A. albomaculata* damage tender leaves by making spindle shaped folds. Two to four terminal leaves are folded longitudinally one above the other and fastened with silken threads to form a tight tubular roll at the growing point. Light yellowish larvae of *C. tiselaea* cause damage by folding leaves terminally. While, larvae of *Macalla albifusa* Hamps. join the leaves one above the other by silken threads and feed on them. Larvae are very active and wriggle out when disturbed and the damaged portion dries up gradually. In few places, larvae of *S. auranticollis* during their early stages roll the tender leaves and scrape the green matter, later they defoliate the entire leaves.

Management measures:

Since damage resulted by these pests is very less, spraying may not be required. Besides, natural enemies including parasitoids take care of these pests. *Cotesia* sp. (Braconidae) and *Chrysocharis* sp. (Eulophidae) parasitize larvae of *C. tiselaea* to a

great extent. But under severe incidence, spraying of quinolphos (2 ml/ lit) or profenophos (1.5 ml/lit) or monocrotophos (1.5 ml/lit) or fenitrothion (1 ml/lit) or lambda-cyhalothrin (0.6 ml/lit) on affected plants manage this pest.

f. Stem and bark feeders

Caterpillars of *Inderbela tetraonis* Moore make a small residential hole on the wood normally where the branches fork and from there make superficial galleries inside which they feed on the tissues. Presence of winding galleries on the bark made of powdered bark, faecal pellets and silk webbed together indicates this pest attack. Feeding damage of cambial tissues of small branches by this larva results in drying up of those branches. The eggs are laid under loose bark and larvae are pale brown with dark head move along the branches concealed under the gallery. Larval period lasts even up to 10-11 months while, pupal period lasts 15-25 days.

Management measures:

To manage bark eating caterpillar, removal of galleries plastered on tree trunk or pouring of kerosene during early stage of infestation is suggested. In the chemical method, application of quinolphos (2 ml/lit) or dichlorvos (2 ml/lit) either by injection or by inserting a cotton swab soaked in the chemical is the most widely used method.

g. Leaf and blossom webber *Lamida* (*Macalla*) *moncusalis* Wlk. (Pyralidae: Lepidoptera)

Cashew shoots bearing fresh flushes and flowers are attacked by leaf and blossom webbing caterpillar, *Lamida* (*Macalla*) *moncusalis* Wlk. especially in East coast tracts of India. Symptoms of infestation are presence of webbing on terminal portions, with clumped appearance, and drying of webbed shoot/ inflorescences. Galleries of silken webs reinforced with plant scraps and castings, indicate the presence of caterpillars. Other crops affected by this pest include Mango, jamun and Indian marking nut tree.

Management measures:

In East coast regions, leaf and blossom webber is parasitized by braconids (*Apanteles* spp.), elasmid (*Elasmus* sp., *Elasmus johnstonii* F.) and a tachinid fly (*Blepharella lateralis*) in Andhra Pradesh and Odisha and a maximum of 50 % parasitism has been reported. While in Kerala, *Apanteles* sp. and *Avga choaspis* (Nixon) (Braconidae) occur as parasitoid on leaf and blossom webber. The green lace wing, *Chrysoperla* sp. also predate on this pest. Spraying of monocrotophos (1.5 ml / lit) or fenitrothion (1 ml / lit) or lambda-cyhalothrin (0.6 ml / lit) can manage this pest.

h. Apple and nut borers: *Thylacoptila paurosema* Meyrick, *Hyalospila leuconeurella* Ragonet, *Nephopteryx* sp. and *Anarsia epotias* Meyrick (Lepidoptera).

Cashew apples are also nutritious and attracted by many insect pests during various developmental stages throughout cashew growing regions. Pest incidence is high in Kerala, Karnataka, Tamil Nadu and Maharashtra. Larvae of *Thylacoptila paurosema* attack tender apples and nuts. Dark pink larvae initially damage flowers by webbing the panicles and feed the unopened flower buds. Then they bore inside the tender nuts and developing apples resulting in shrivelling and premature fall. In the developed green nuts and apples, larvae tunnel near the junction of apple and nut and the boreholes are plugged with frass and excreta. The caterpillars of *Hyalospila leuconeurella* bore through the apple from one end to the other and remain inside the apple till the fruit drops. Attacked apples generally fall down from the trees. Nuts when attacked become severely deformed. Similarly, *Nephopteryx* sp. (Pyralidae: Lepidoptera) is common in Tamil Nadu and Andhra Pradesh attacking fruits at all stages of development causing up to 60 per cent of nut damage. The larvae scrape the epidermis of tender nuts and apples and move to the point of attachment of nut and apple. The entry hole is minute and plugged with the excreta. The infestation spoils the apples and nuts, larvae also feed on the kernel.

Management measures:

Removal and destruction of infested inflorescences as well as infested apples and nuts having larvae can be followed to prevent spread of the pest. Three larval parasitoids *viz*., *Panerotoma* sp., (Braconidae), *Trathala flavorbitalis* (Ichneumonidae) and one unidentified tiny dipteran fly occur on apple and nut borer larvae and a maximum of 46.2 to 50 % parasitism has been recorded under field conditions. Spraying of carbaryl (1 ml/lit) or lambda cyhalothirn (0.6 ml/lit) or quinolphos (2 ml/lit) or dichlorvos (1 ml/lit) is found effective for apple and nut borers.

i. Mealybugs *Planococcus citrii* Risso, *Planococcus lilacinus* Cockrell and *Ferrisia virgata* Cockrell, *Planococcoides robustus* Ezzat and Meconnel.

Mealybugs are potential pests in case of cashew. It occurs in Karnataka, Kerala, Tamil Nadu, but severe in Konkan region and Goa. Mealybug colonies develop on tender vegetative shoots, leaves, inflorescence, tender nuts and fruits. Damaged flowers wither and dry, while the fruits shrivel, under develop or sometimes dry up. Due to honey dew secretion by mealy bugs, sooty mould develops on the affected portions.

Management measures:

Removal and destruction of mealy bug infested plant parts help to minimize their infestation and spread. *Apanteles* sp. has been reported as a parasitoid on *F. virgata*, besides *Blepyrus insularis* Cameron. In Kerala, up to 35 % parasitism has been reported in *F. virgata* to be caused by *Aenasius advena* Campere (Encyrtidae). In Karnataka also, *A. advena* could cause upto 50 % parasitism in *F. virgata*. If essential, spraying of profenophos (2 ml/lit) or chlorpyriphos (2ml/lit) or dimethoate (2 ml/lit) or

thiamethoxam (0.6 g/lit) or imidacloprid (0.6 ml/lit) may be followed to manage mealy bugs in combination with fish oil Rosin soap at 20 g/lit.

General considerations in management of minor insect pests of cashew

- Generally, chemical sprays taken up against tea mosquito bug usually take care of the infestation of most of the foliage pests, hence spraying for other pests is required only under severe infestation.

- Proper surveillance and regular monitoring of the pest situation has become essential to rationalize their management strategies so as to avoid the need for blanket insecticidal sprays. Removal of weeds in cashew plantations should be taken care, because, weeds especially *Terminalia paniculata*, *Chromolaena odorata* are not only competitors of cashew but also serve as host plants for many of the cashew pests.
- In young cashew plants, wherever possible, removal of different stages of pests like egg laden leaves or shoots, caterpillars, pupa or cocoons, grubs from the infested plants gradually reduces the pest population. Removal and destruction of mealy bug and aphid infested plant parts helps to minimize their infestation and spread.

- Spraying should be taken up before 9 am or after 4 pm in order to save cashew pollinators.

- Under unsprayed conditions, an array of predators *viz*., spiders, ants, reduviids, coccinellids, neuropterans, hemipteran bugs and praying mantises take care of many of the cashew pests. Red ants (*Oecophylla smaragdina*) are the potential biocontrol agents in cashew plantations that feed on bugs, caterpillars, hoppers, moths etc. Red ant colonized old cashew trees are generally free from pests. Apart from predators, there are also parasitoids that take care of several cashew pests. Hence, indiscriminate spraying may be avoided. Trees harbouring ant nests especially red ants should be spared of spraying to allow them to take care of pests naturally.

- Botanical insecticides like Neem (*Azhadirachta indica*) oil @ 3-5%, Karanj (*Pongamia pinnata*) oil @ 2%, Fish Oil Rosin Soap and neem seed kernel extract @ 5 % are some of the botanical preparations effective against many of the foliage pests of cashew like leaf miners and leaf feeding caterpillars.

MANAGEMENT OF DISEASES IN CASHEW

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Introduction

Cashew (*Anacardium occidentale* L.) is one of the important horticultural cash crops in India and it accounted for 7.53 lakhs tones of production from 10.11 lakhs ha area with an average productivity of 0.7 t/ha during 2013-14 (NHB 2014). However, productivity of cashew is low in comparison to optimum productivity (≈2.0 t/ha), possibly due to hindrance by abiotic and biotic factors. Among the biotic factors, diseases such as anthracnose (*Colletotrichum gloeosporioides*), black mold (*Pilgeriella anacardii*), angular leaf spot (*Septoria anacardii*), and blight/floral shoot and twig die back (*Lasiodiplodia theobromae*) are considered as major yield limiting factors. Average yield losses due to diseases have been estimated as 40-50% (Olunloyo, 1979). However, inflorescence blight/ floral shoot and twig die back has been designated as serious one as it alone could cause reduction of nut yield by 70% and more than 50% death of vegetative shoot (Olunloyo1979; Hammed et al 2008). Management of such diseases needs precise diagnosis/identification of diseases. Hence in this chapter, details of different diseases, identification and management have been dealt.

1. Anthracnose

Symptoms

The disease is caused by *Colletotrichum gloeosporioides*. Both young and adult plants are susceptible to the disease. All parts (leaves, twigs, inflorescences, young apples and fruits) of the plants are prone to attack by the pathogen. Symptoms include initial water soaked lesions on leaves and later they turn into orange-brown to light reddish. Under severe conditions, both leaves and fruits may completely blight and drop. The disease spreads fast during high rain and temperature around 22 to 28°C. The disease may drastically reduce the yield and quality of apple and kernel.

Management

- Pruning severely infected parts and spraying of copper hydroxide (0.3%) or copper oxychlorate (@0.2%) may be followed.

- Careful monitoring is required during new flush, flowering and fruiting stages for infection and spread of the disease as the young tissues are susceptible and accordingly spraying should be taken.

2. Black mold disease

Symptoms

Black mold disease caused by *Pilgeriella anacardii* is considered as one of the most important foliar diseases of cashew. It produces black to dark brown colonies with chlorotic spots on leaves. In severe condition, the infected leaves fall down. Normally the young leaves are not affected by this disease. Other symptoms include, yellowing of foliage, shortening of internodal length, and severely infected plants show less foliage with short nature.

Management

- Spraying of Bordeaux mixture (1.0%) may control the disease

3. Angular leaf spot

Symptoms

It is caused by the fungus *Septoria anacardii*. It produces dark brow margin with light brown or gray or cream colour spots on the leaves. The spots are confined to angular region of the veins hence the disease is named as angular leaf spot. Both young nursery seedlings and orchard plants are affected by this disease.

The disease is more severe on young ones than the adult plants. The spots are deep dark or black with chlorotic halo on the matured leaves of older seedlings.

Management

- Prophylactic spray of mancozeb (@ 0.2%) can be given on seedlings.
- At the initial stage of infection spray of carbendazim (@ 0.1%) may be followed.

4. Inflorescence blight /floral, shoot and twig die back/Gummosis

Symptoms

Symptoms of Inflorescence blight/floral shoot and twig die back caused by *Lasiodiplodia theobromae* include withering of floral parts and progressive die back of inflorescence, shoot and twigs. On the trunk, oozing of gummy exudates is observed. Other symptoms included yellowing and dropping of leaves, and gum infected stems show dark colour with cracking. Severe cases the fungus may enter deeply into the stems and stop the sap flow. Wounds created by insects act as predisposing factor for the disease infection.

In India, it has been reported that the disease is predisposed by tea mosquito bug (TMB) (*Helopeltis antonii*) or combined attack by both TMB and the fungus. Hence, spraying of insecticide to manage the insect is essential.

Management

- Sanitation including removal of infected twigs and bark, and plugging the cut end with Bordeaux paste (@ 10%).
- Insecticidal sprays for timely management of TMB is essential, since TMB is considered as predisposing factor for the disease.
- Spraying of Bordeaux mixture (1.0%) may control the disease at the initial stage of infection.

Conclusion

As the diseases also considered as one of the major biotic factors which limits the yield of cashew, management practices as discussed should be adopted. It is also important to use correct dose of fungicides as they are not effective at low concentration and may cause residual problems at high concentration.

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