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Recommendations

Integrated Pest Management of Longan (Sapindales: Sapindaceae) in Vietnam

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Abstract

This paper describes the current state of pests and diseases of longan (*Dimocarpus longan* Lour.) and their management in Vietnam. Longan is the third most cultivated fruit crop and second major fruit crop exported from Vietnam. Brief descriptions of arthropod pests *Eriophyes dimocarpi* Kuang (Acari: Eriophyidae), *Conogethes punctiferalis* Guenée (Lepidoptera: Crambidae), *Conopomorpha sinensis* Bradley (Lepidoptera: Gracillariidae), *Conopomorpha litchiella* Bradley (Lepidoptera: Gracillariidae), *Tessaratoma papillosa* Drury (Hemiptera: Tessaratomidae), *Eudocima phalonia* L. comb. (Lepidoptera: Erebidae), oriental fruit fly *Bactrocera dorsalis* Hendel (Diptera: Tephretidae), *Planococcus lilacinus* Cockerell (Hemiptera: Pseudococcidae), *Drepanococcus chiton* Green (Hemiptera: Coccidae), and *Cornegenapsylla sinica* Yang & Li (Hemiptera: Psyllidae) and fungal diseases *Phytophthora palmivora* Butler (Peronosporales: Peronosporaceae), *Colletotrichum gloeosporioides* (Penz.) Penz. & Sacc. (Incertaesedis: Glomerellaceae), and *Ceratocystis fimbriata* Ellis & Halsted (Microascales: Ceratocystidaceae) affecting longan are given. The longan witches' broom syndrome is a major factor causing 50–86% annual crop loss in Vietnam and it has been considered the primary constraint in production. The causative agent of this syndrome has been identified as the eriophyid mite *E. dimocarpi*. Deployment of Integrated Pest Management strategies for longan production in Vietnam is outlined.

Key words: longan IPM, witches' broom, Vietnam

Tropical fruits make a significant contribution to the economy of Vietnam and nearly half of them are produced in the Mekong Delta region. This region is an important economic center supporting over 15 million people and contributing over 27% of Vietnam's national GDP. The longan [(*Dimocarpus longan* Lour. (Sapindaceae)] is a perennial fruit tree (Waite and Hwang 2002) (Fig. 1). China, Thailand, and Vietnam are major producers of longan. It is cultivated mostly in Vinh Long, Tien Giang, and Ba Ria-Vung Tau provinces of southern Vietnam. In 2016, longan was planted over an area of 73,600 ha in Vietnam and it is the third most cultivated fruit crop after mango and banana, and the second most exported crop behind dragon fruit (Department of Crop Production 2017).

The export value of longan in Vietnam was $62.13 million in 2017. Fresh longan has been exported to the U.S. and European Union markets with an increasing volume in the last 4 yr, with export potential still to increase. The trees begin production 2 to 3 yr after planting. Normal flower initiation occurs in late winter and flowers open in early spring (Waite and Hwang 2002) (Fig. 2). However, many farmers in Vietnam induce flowers at different times of the year by ringing the stems and applying potassium chlorate to the soil, which enables them to harvest fruits throughout the year. Pruning is done every year after harvest to maintain suitable height and for pest and disease management.

Pests and Diseases

Pests of longan are known to cause 50 to 100% crop losses unless timely interventions are implemented (Department of Plant Protection 2015). Arthropod pests that attack longan and their natural enemies in different countries have been reviewed by Waite and Hwang (2002). The major pests of longan in Vietnam are *Eriophyes dimocarpi* (Kuang) (Acari: Eriophyidae), *Conogethes*

Fig. 1. Longan tree with fruits.

Fig. 2. Inflorescence of longan.

punctiferalis Guenée (Lepidoptera: Crambidae), *Conopomorpha sinensis* Bradley (Lepidoptera: Gracillariidae), *Conopomorpha litchiella* Bradley (Lepidoptera: Gracillariidae), *Eudocima phalonia* (L.) comb. (Lepidoptera: Erebidae), *Tessaratoma papillosa* (Drury) (Hemiptera: Tessaratomidae), oriental fruit fly *Bactrocera dorsalis* Hendel (Diptera: Tephretidae), *Planococcus lilacinus* (Cockerell) (Hemiptera: Pseudococcidae), *Drepanococcus chiton* (Green) (Hemiptera: Coccidae) and *Cornegenapsylla sinica* Yang & Li (Hemiptera: Psyllidae). Major diseases include fruit rot *Phytophthora palmivora*, anthracnose *Colletotrichum gloeosporioides*, and Ceratocystis blight *Ceratocystis fimbriata* (Common wealth of Australia 2004, Waterhouse 1993, Waite and Hwang 2002, H.T., unpublished data).

Eriophyes dimocarpi (Kuang) (Acari: Eriophyidae)

It occurs in China, Hong Kong, Taiwan, Thailand, and Vietnam (So and Zee 1972, Menzel et al. 1989, Tri 2004). Females lay white colored spherical eggs on developing buds and hatch in about 5.10 ± 1.37 d. The mite has two nymphal instars lasting 6.4 ± 0.79 d. First-instar nymphs are white, 0.06 ± 0.006 mm long, while second-instar nymphs are white, 0.09 ± 0.01 mm long, and both have two pairs of legs. Adults are white, 0.12 ± 0.008 mm long and live 2.2 ± 0.52 d (Fig. 3). Average life cycle is completed in 13.70 ± 2.16 d. The mites are abundant from November to May, coinciding with the dry season. It has been reported to be associated with longan witches' broom syndrome (LgWB) (He et al. 2001, Hanh et al. 2012a, Hoat et al. 2017).

Fig. 3. *Eriophyes dimocarpi* (Kuang).

Fig. 4. Longan tree with witches' broom syndrome affected shoots.

Fig. 5. Witches' broom syndrome affected shoot.

Witches' broom on longan was first reported in China in 1941 and later in Thailand, Hong Kong, Taiwan (So and Zee 1972, Menzel et al. 1989) and Cambodia (R. Muniappan, personal observation, 2018). In Vietnam, it appeared in the north in 1999 with an apparent introduction from China, and in the south in 2001 (Tri 2004). It is considered as one of the important constraints of longan and rambutan production in Vietnam. Trees affected by LgWB have short vegetative shoots with small leaves showing curling of leaf

Fig. 6. Leaf with witches' broom syndrome.

margins, shortened inflorescence with malformed flowers, and panicles poorly filled with small fruits (So and Zee 1972, Kuang 1997, Zhang and Zhang 1999) (Figs. 4–6). The crop losses caused by LgWB vary from 50 to 86% in the fields (Zhang and Zhang 1999, Chen and Xu 2001, Hoat et al. 2017). Studies conducted to identify the causative organism of LgWB in China, Thailand, and Vietnam have attributed it to virus (So and Zee 1972, Ye et al. 1990, Chen et al. 1996, Chen and Xu 2001), phytoplasma (Visitpanich et al. 1996, Hoa et al. 2012), and association of *E. dimocarpi* (He et al. 2001, Hoat et al. 2017).

One of the objectives of the USAID-funded IPM Innovation Lab project instituted at the Southern Horticultural Research Institute (SOFRI) in Vietnam in 2015 was to identify the causative organism of LgWB of longan. To verify the presence of phytoplasma or virus, samples of affected longan shoots from Southern Vietnam were sent to the laboratory of Dr. Robert Gilbertson, University of California-Davis, and to Dr. Rayapati Naidu, Washington State University, Prosser. The diagnostic efforts at these two institutions to find phytoplasma or virus in the samples proved negative. Studies carried out by SOFRI in collaboration with Molecular Biology Divisions of the Can Tho University, Molecular Biology Division of the Nong Lam University, Electron Microscope Department of Institute of Hygiene and Epidemiology in Hanoi, and Central Analysis Laboratory of National Science University at Ho Chi Minh City also failed to identify phytoplasma, bacteria, fungi, or virus in LgWB samples from Southern Vietnam (Hanh et al. 2012a,b).

It is known that eriophyid mites cause necrosis, enations, fasciation, various galls, and witches' broom on several plants (Jeppson et al. 1975, Westphal and Manson 1996). Recent findings of Dr. Hanh Tran's work at SOFRI has confirmed that *E. dimocarpi* is the causative agent of LgWB and it is not a vector of viruses or phytoplasma that were speculated to be causative agents of the syndrome (H.T., unpublished data).

For management of longan witches' broom infected shoots and inflorescences on longan trees should be removed and destroyed. The alternate host of the longan gall mite, rambutan, should not be grown in longan orchards (Hanh et al. 2014). Flower inducement from April to June should be avoided as this coincides with the peak period for *E. dimocarpi* (Hanh et al. 2012b). Prophylactic application of sulfur compounds, neem oil or petroleum oil spray reduces incidence of LgWB. The predatory mite, *Amblyseius* sp. (Acari: Phytosiidae) and *Arthrocnodax* sp. (Diptera: Cecidomyiidae) were

Fig. 7. Larva of *Conogothes punctiferalis* Guenee.

Fig. 8. *Conogothes punctiferalis* damaged fruits.

found feeding on *E. dimocarpi* at the Mekong Delta fields (Hanh et al. 2014). In addition, entomopathogenic fungus, *Paecilomyes* sp. was found infecting *E. dimocarpi* in the field. Reducing use of toxic pesticides will lead to adoption of conservation biological control, which will enhance the population of local natural enemies.

Conogethes punctiferalis Guenée (Lepidoptera: Crambidae)

It is widely distributed in South and East Asia, Australia, and Papua New Guinea (CABI 2011). It is a polyphagous pest with broad host range (Sekiguchi 1974, Waterhouse 1993, Li et al. 2015). The adults are medium-sized moths with wingspans of 20–23 mm, the forewings are peach-yellow in color with scattered black spots and it lives 8–11 d (Fig. 7) (Ganesha et al. 2013). The moths lay yellowish white eggs that hatch in 2–4 d (Ganesha et al. 2013). The first instar larvae are light pinkish brown in color with pale black spots. The older larvae are light brown in color with dark brown heads and dark spots on the body. Larvae bore into the fruits and presence of frass on the fruit surface is one of the characteristics of this insect infestation (Fig. 8). It pupates in soil and sometimes on fallen leaves, and pupal duration is 7–9 d (Ganesha et al. 2013).

Pheromone and/or light traps could be set up to monitor the adult moth population in the field. Bagging fruit clusters at 15 d after fruit set reduces damage by this pest (Fig. 9). Collecting and destroying infested fruits is recommended in small orchards. Application of neem formulations repels moths laying eggs on the fruits. In India augmentative release of *Trichogramma* sp. (Hymenoptera: Trichogrammatidae) and *Chelonus blackburni* Cameron (Hymenoptera: Braconidae) is used for control of this pest (Chakravarthy et al. 2015).

Fig. 9. Longan fruit clusters covered with bags.

Conopomorpha sinensis Bradley (Lepidoptera: Gracillariidae)

It is a major pest of litchi and longan in China, Taiwan, Thailand (Waite and Hwang 2002), and Vietnam (APHIS/USDA 2011). The moths lay cream-colored, scale-like eggs on the shoots or fruits (Waite 2005). The eggs hatch in 3–5 d and the neonate larvae immediately bore into the shoots or fruits (Schulte et al. 2007). One or more eggs may be laid on a shoot or a fruit, but generally only one larva survives on each shoot or fruit. Mature larvae are brownish or green in color, and 6–10 mm in length. The larval duration is 10–12 d. Pupation takes place within the cream-colored, oval cocoon under mature leaves and the adults emerge after 5–7 d (Waite and Hwang 2002). The adults are straw-colored moths with long filiform antennae, fringed forewings, and it lives 5–8 d. In absence of fruits, the larvae survive by feeding on young leaves or shoots (Waite and Hwang 2002).

When the egg laid on the fruit surface hatches, the larva bores into the fruit, feeds on the seed, (Fig. 10a and b) causing the fruit to be prone to infection by various microorganisms and fruit drop (Huang et al. 1994, Wang et al. 2008). Huang et al. (1994) found 96.1–100% of fallen fruits and 41.5–96.7% of fruits remaining on the trees were damaged by this pest in unsprayed orchards.

Bagging of fruits and application of neem formulations recommended for *C. punctiferalis* are effective in management of this pest (Fig. 9). Pheromone and/or light traps could be used for monitoring the population. In Taiwan, the larval parasitoids *Tetrastichus* sp. and *Elasmus* sp. (Hymenoptera: Eulophidae) and pupal parasitoids *Phanerotoma* sp. and *Apanteles* sp. (Hymenoptera: Braconidae) were reported. In Thailand, *Apanteles briaeus* Nixon, *Chelonus chailini* Walker and Huddleston, *Colastes* sp., *Phanerotoma* sp., *Pholestesor* sp. (Hymenoptera: Braconidae), and *Goryphus* sp. (Hymenoptera: Ichneumonidae) were found parasitizing larvae (Waite and Hwang 2002, Schulte et al. 2007).

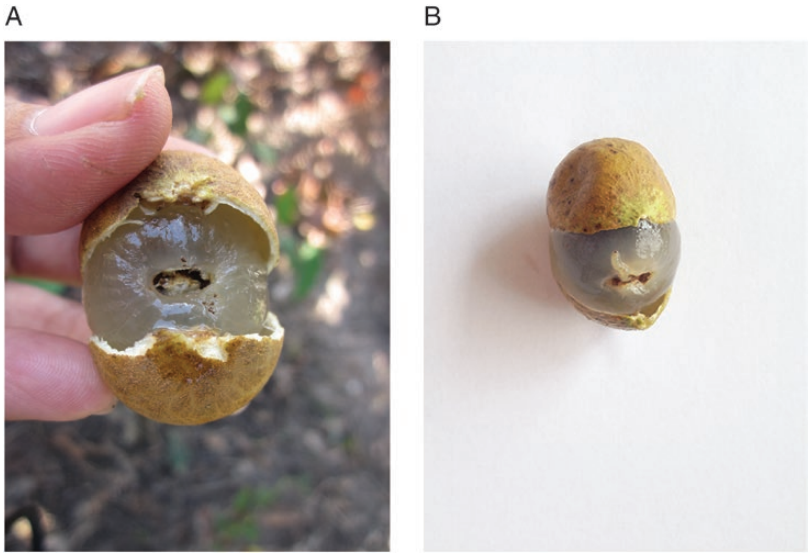

Fig. 10. (a,b) *Conophomorpha sinensis* Bradley damaged fruits.

Conopomorpha litchiella Bradley (Lepidoptera: Gracillariidae).

The adult females lay small, light-yellow eggs on new shoots and they hatch in 3–5 d. The newly hatched larvae are pale green and mine in the leaf blades. The mature larvae prefer to feed on the mid-rib and veins of young leaves (Fig. 11). There are five larval instars and the larval period is about 10–14 d (Waite and Hwang 2002). Pupae are light green when formed and later change to golden brown. Pupation takes place on mature leaves covered by a thin silken web and the pupal stage lasts 7–10 d. The life cycle is completed in 25–30 d.

Fig. 11. *Conophomorpha litchiella* Bradley damaged leaves.

All development stages of this leafminer are similar to those of litchi fruit borer. Larvae bore into the midribs, causing distortion and twisting of young leaves. The density of *C. litchiella* infestation is high during the rainy season from June to September in Vietnam. In severe infestations, affected shoots should be pruned and disposed of. The same species of parasitoids attack both *C. sinensis* and *C. litchiella*.

Tessaratoma papillosa Drury (Hemiptera: Tessaratomidae)

It occurs in China, India, Indonesia, Malaysia, Pakistan, Philippines, Sri Lanka, Taiwan, Thailand, and Vietnam (CABI 2002). It is known to feed on 21 species of plants, but the favored ones are lychee and longan. Adults (Fig. 12) are golden brown and measure 25–30 mm long and 15–17 mm wide (Quynh 2016). Eggs are round and light green when laid and gradually become yellowish brown (Commonwealth of Australia 2004). The newly hatched nymphs are elliptical, at first reddish, and later turn dark-blue. Second-instar nymphs are rectangular and are orange-red with a dark-gray margin. There are five nymphal instars and the total lifecycle duration is about 60–80 d.

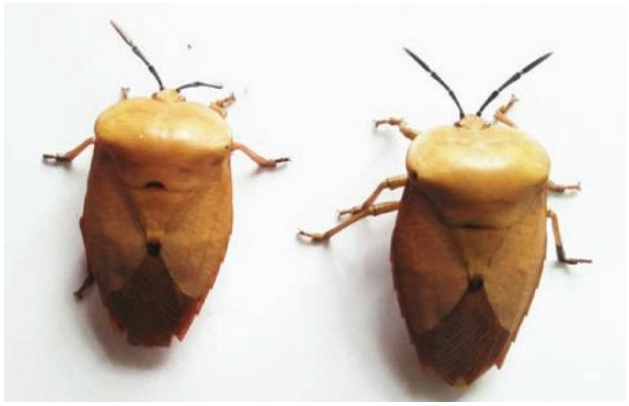

Fig. 12. Adults of *Tessaratoma papillosa* Drury.

Tessaratoma papillosa has one generation per year, and overwinters as adults. In spring, the overwintering adults do not mate immediately, as their reproductive organs are not mature. Females mate multiple times and lay up to 14 egg masses, each containing about 14 eggs on the lower surface of leaves (Waite and Hwang 2002). Both nymphs and adults feed on tender plant parts like shoots, inflorescence, and fruits (Boopathi et al. 2015). The feeding causes necrosis of young twigs, withering of flowers, fruit rot, and eventually fruit drop (Quynh 2016). Although the pest infestation can be seen year around, damage is more prevalent in summer and low in the rainy season (Boopathi et al. 2011). It typically causes 20–30% yield loss and if the infestation is heavy it may reach 80–90% (CABI 2002).

Augmentative biological control of *T. papillosa* should be considered. Egg parasitoids *Encyrtus* sp., and. *Anastatus* sp., are key mortality factors in the field. Augmentative release of *Anastatus japonicus* (Ashmed) has been practiced in China since 1960s (Li et al. 2014). In China, the egg parasitoids, *Encyrtus* (*Ooencyrtus*) sp., (Hymenoptera: Encyrtidae) *Anastatus* sp. (Hymenoptera: Eupelmidae), and *Blastophaga* sp. (Hymenopera: Agaonidae) were reported to parasitize 70 to 90% of eggs laid late in the season (Waite and Hwang 2002). Similar late season results were achieved in Thailand by mass releasing *A. japonicas* (Ashmead) and *Ooencyrtus phongi* (Nanta 1988). *Beauveria bassiana*, *Paecilomyces* sp., and *Metarhizium* sp. are effective in controlling stink bug populations, particularly during the wet season.

Fig. 13. Adult *Eudocima phalonia* (L.) Comb.

Eudocima phalonia (L.) comb. (Lepidoptera: Erebidae)

Fruit piercing moths occur along the tropical belt, except in the Americas (Waterhouse and Norris 1987). *Eudocima phalonia* (Fig. 13) is one of the common species whose larvae (Fig. 14a and b) on vines of the family Menispermaceae in most parts of the world (Cochereau 1977), and in addition *Erythrina* spp. (Fabaceae) in the Pacific Islands and *Leea indica* (Leeaceae) in Thailand and Malaysia (Muniappan et al. 1994/1995, Reddy et al. 2005, Leong and Kueh

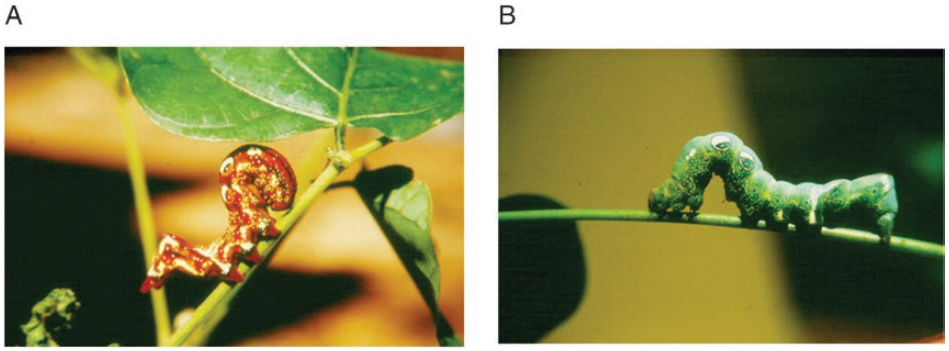

Fig. 14. (a,b) Larvae of *Eudocima phalonia*.

Fig. 15. Adult *Eudocima phalonia* feeding on an orange fruit.

2011). The moths drill holes in the fruits and suck the juice at night (Fig. 15). Microbial contamination from the probosces of these moths results in rotting of the pierced fruits. Bagging of fruits effectively prevents damage by this moth. Waterhouse (1993) reported it to be a pest of longan in Vietnam but additional information is lacking from this country. Egg parasitoids *Trichogramma* sp., *Telenomus* sp. (Hymenoptera: Platygastridae), and *Ooencyrtus* sp. (Hymenoptera: Encyrtidae), and larval parasitoids *Euplectrus* spp. (Hymenoptera: Eulophidae), and *Winthemia* sp. (Diptera: Tachinidae) have been reported from Asia and the Pacific islands (Waterhouse and Norris 1987).

Oriental Fruit Fly *Bactrocera dorsalis* Hendel (Diptera: Tephritidae)

Oriental fruit fly is a polyphagous pest with a wide host range of over 200 host plants in 40 families (Prokopy et al. 1990) and it has been reported from Vietnam (Drew and Hancock 1994, Vargas et al. 2015). Oriental fruit fly (Fig. 16) lays pale yellow eggs under the skin of ripened or ripening fruits. The physical damage caused by ovipositional punctures as well as feeding damage by maggots leads to rotting of fruits (De Villiers 1992). Bagging fruits effectively prevents damage by this pest. A locally developed protein bait called SOFRI-PROTEIN, made from beer waste and an insecticide, attracts both male and female flies and kills them. Additionally, setting up methyl eugenol traps attracts and kills male flies. These techniques in combination with orchard sanitation are effective in managing the

Fig. 16. Oriental fruit fly, *Bactrocera dorsalis* Hendel.

fruit fly. However, for export of fruits, either hot vapor or irradiation treatments are required.

Planococcus lilacinus Cockerell (Hemiptera: Pseudococcidae)

It is distributed throughout the tropics in the world. The female adults lay 55–152 eggs per mass. Eggs hatch within 24 h. The nymphal period lasts 20–25 d (Loganathan and Suresh 2001). This mealybug population increases during the dry season from February to May in Vietnam (H.T., personal observation) (Fig. 17). Pruning and destroying infected shoots can reduce mealybug populations. SOFRI-ant bait controls ants and that helps to reduce mealybug population as ants interfere with parasitoids and predators attacking mealybugs. The ladybird beetles *Menochilus sexmaculatus* (Fabricius), *Coccinella transversalis* Fabricius, and *Cryptolaemus montrouzieri* Mulsant (Coleoptera: Coccinellidae) and Lacewing *Suarius* sp. (Neuroptera:

Fig. 17. *Planococcus lilacinus* Cockerell.

Fig. 18. *Drepanococcus chiton* (Green) infesting papaya fruit.

Chrysopidae) are effective natural enemies of mealybugs. *Paecilomyces* sp., and *Metarhizium* sp. are effective in controlling mealybug populations in the wet season (H.T., unpublished data). Mani (1995a) reported the parasitoids, *Tetracnemoidea indica* Ayyar (Hymenoptera: Encyrtidae), and *Aprostocetus purpureus* (Hymenooptera: Eulophidae), and the predators *Spalgis epius* Westwood (Lepidoptera: Lycaenidae), *Brumus* sp., *Scymnus coccivora* Ayyar, *C. montrouzieri* (Coleoptera: Coccinellidae), *Triommata coccidivora* Felt (Diptera: Cecidomyiidae), and *Cacoxenus perspicax* Knab (Diptera: Drosophilidae) on *P. lilacinus* in India. Further, he reported *T. indica* was very effective in suppressing this mealybug population.

Drepanococcus chiton (Green) (Hemiptera: Coccidae).

It occurs in south and southeast Asia. Ibrahim (1994) reported it to complete its life cycle in 50 d at 29°C and each female to produce about 1,200 eggs (Fig. 18).

This soft scale sucks the sap from host plants and excretes a large amount of honeydew on fruits and leaves, leading to growth of sooty mold (Smith et al. 1997). In severe infestations, fruits are underdeveloped and drop off. Shipments of longan and lychee with *D. chiton* from Vietnam have been intercepted in the U.S. ports (Miller et al. 2014). Setting up ant baits to control ants in the trees enhances parasitism and predation and reduces this soft scale population. Natural enemies recorded were *Coccophagus thanhoaensis* Sugonyev (Hymenoptera: Aphelinidae) in Vietnam (Sugonyaev 2011), *Eunotus*

Fig. 19. Adult *Cornegenapsylla sinica* Yang & Li.

Fig. 20. Leaves with *Cornegenapsylla sinica* galls.

sp. (Hymenoptera: Pteromalidae) in Malaysia (Ibrahim 1994), and *Anicetus ceylonensis* How., *Metaphycus* sp. nr *helvolus* (Howard), and *Philosindia* sp. nr *longicornis* Noyes and Hayat (Hymenoptera: Encyrtidae), *Cephaleta brunniventris* Motschulsky (Hymenoptera: Pteromalidae), *Chilocorus nigrita* (Fabricius), *C. montrouzieri*, *M. sexmaculata*, and *Scymnus* sp. (Coleoptera: Coccinellidae) in India (Mani 1995b).

Cornegenapsylla sinica Yang & Li (Hemiptera: Psyllidae).

The female adults are small with an average size of 1.7 × 0.36 mm (Fig. 19), and the male adults are 1.4 × 0.33 mm long. Eggs are pale yellow in color and are laid singly into the veins on the under surface of the leaves (Fig. 20). There are four nymph instars and they remain inside the galls. The psyllid completes its life cycle in about 53 d. There are 3–5 generations per year. The psyllid is most abundant from April to June (H.T., unpublished data). Pruning and disposal of the severely affected shoots is recommended.

Fruit Rot *Phytophthora palmivora* Butler (Peronosporales: Peronosporaceae)

The disease attacks the longan trees from flowering stage to fruit harvest. *Phytophthora palmivora* can survive in the soil and it spreads

Fig. 21. Anthracnose infected leaflets.

Fig. 22. Trees killed by ceratocystis blight.

through irrigation water. In addition, humans and ants also contribute to its spread. It affects young shoots, panicles, and fruits. Symptoms are necrosis of young shoots, flower drop, irregular lesions on fruits, and premature fruit drop (Coates et al. 2003, 2005). The disease causes severe damage during the rainy season, and all longan varieties in Vietnam are susceptible to fruit rot. Proper aeration and reducing humidity by pruning, removing, and destroying infected fruits decrease disease incidence. Fungicides are effective in controlling fruit rot.

Anthracnose *Colletotrichum gloeosporioides* (Penz.) Penz. & Sacc. (Incertaesedis: Glomerellaceae)

It is an important disease of litchi but is of minor importance on longan. It can attack both leaves and fruits. Symptoms on older leaves that appear as small spots in the margins coalesce to form large patches with brown borders (Fig. 21). On young leaves, water-soaked lesions appear first and later turn dark brown and dry up. On fruits, dark brown lesions appear on the surface. Under wet conditions, white mycelial growth and fungal fruiting bodies may also cover the lesions (McMillan 1994). Control method recommended for fruit rot also applies for anthracnose.

Ceratocystis Blight *C. fimbriata* Ellis & Halsted (Microascales: Ceratocystidaceae)

Initially infected branches start wilting and eventually the whole tree succumbs (Fig. 22). The same fungus, *C. fimbriata* causes 'seca', 'murcha', or 'mango blight' on mango. Abiotic factors such as water stress, extreme high or low temperatures, and micro-nutrient deficiency enhance the damage caused by this fungus (Ploetz 2003). Scolytid beetles, wounds caused by contaminated tools used for pruning, and ringing transmit this disease to healthy plants. The variety Tieu Da Bo is more susceptible to this disease in Vietnam. Pruning and disposal of the affected branches is recommended.

IPM Program for Longan

Components

1. Fertilize the trees with compost inoculated with the antagonistic fungus, *Trichoderma* sp.
2. Do not induce flowering during November to May.
3. Immediately after the final harvest, prune the trees and safely dispose of the material either by burying or burning.
4. Prune and destroy shoots infected by LgWB syndrome.
5. Set up light and/or pheromone traps to monitor fruit borer, litchi shoot borer, leafminer, and other pests.
6. Set up methyl eugenol traps and protein bait for controlling fruit flies.
7. Set up SOFRI-ant baits for controlling ants, mealybugs, and soft scale.
8. Apply *Beauveria bassiana*, *Paecilomyces* sp., or *Metarhizium* sp. for controlling stink bug.
9. Spray sulfur, neem oil, petroleum oil, or *Paecilomyces* sp. to control longan eriophyid mite.
10. Bag the fruit cluster 15 d after fruit set.

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