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Major insect pests of citrus crop and their management: A review

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Abstract
Citrus is one of the most important fruits industries in the world, grown in more than 52 countries around the world. In India, 250 species of insects and mites have been reported infesting different species of citrus. The present study recorded the infestation of Lemon butterfly: *Papilio demoleus* Linn; Papilionidae: Lepidoptera, Leaf miner: *Phyllocnistis citrella* S.*;* Phyllocnistidae: Lepidoptera etc. These pests significantly contribute towards the citrus decline in the region. For management of these pests, diagnosis of the causes of decline, the rejuvenation schedule may be formulated with multidisciplinary approach. More information is needed on some of the key elements required for environmentally friendly management Biological control through augmentation and conservation of parasitoids integrated with other non-pesticide measures need to be tested with holistic approach in citrus.

Keywords: *Papilio demoleus, Phyllocnistis citrella,* rejuvenation, augmentation and parasitoids

Introduction

Brazil and China are the largest producers of citrus worldwide producing about 45 million tons (MT) of citrus fruit together, followed by USA, India, Mexico and Spain with a production of 10.7, 8.6, 7.2 and 5.5 MT, respectively (Mahmood *et al.*, 2014) [2]. In India, citrus is commercially grown in about 10.42 lakh ha with an annual production of 100.90 lakh tones and productivity of 9.7 t/ha (NHB, 2013) and are primarily grown in Maharastra, Andhra Pradesh, Punjab, Karnataka, Uttaranchal, Bihar, Orissa, Assam and Gujarat. It is the high amount content of vitamin-C. Citrus is an exotic plant introduced to Eritrea during the Italian colonial era, produced as a cash crop (MoA, 2006) [3]. However, due to the long war of independence against Ethiopia, the production of citrus fruit reduced sharply and its exportability ceased. After independence citrus cultivation like all other agricultural developments has been rehabilitated and expanded in its area of production in the country except Southern Red Sea region (MoA, 2006) [3]. it is also grown in the valleys of Gash, Anseba, Barka and Sawa (MoA, 2006) [3] and the areas such as Elabered, Ghinda, Solomuna, Keren, Tekreret, Binbina and their vicinities are very conducive for citrus plantations (MoA, 2012) [4]. The losses caused due to insect pests range 50 to 77% in zoba Debub and zoba Anseba together (IPM Team Task Force, 2013) [1]. North Eastern Region is one of the richest reservoirs of genetic diversity of Citrus as the primary as well as the secondary centre of origin of numerous citrus species and has been described as one of the major centre of diversity for citrus in both wild and cultivated forms (Singh *et al.*, 2006) [6]. In India, 250 species of insects and mites have been reported infesting different species of citrus (Wadhi and Batra, 1964) [7]. Bark eating Caterpillar (*Inderbella* spp.)10.80 to 43.76%, Leaf miner (*Phyllocnistis citrella*) 8.70 to 42.01%, Lemon butterfly (*Papilo domelis*) 3.10 to 27.89%, Citrus psylla (*Diaphornia citrii*) 3.12 to 8.36%, Citrus aphid (*Toxoptera citricida*) 9.18 to 11.30% and Citrus Black fly (*Aleurocanthus woglumi*) Fruit Sucking Moth (*Ophederes* sp. *Achaea janata*).

The Six IPM Program Essentials

1. **Monitoring:** This includes regular site inspections and trapping to determine the types and infestation levels of pests at each site.
2. **Record-Keeping:** A record-keeping system is essential to establish trends and patterns in pest outbreaks. Information recorded at every inspection or treatment should include pest identification, population size, distribution, recommendations for future prevention, and complete information on the treatment action.
3. **Action Levels:** Pests are virtually never eradicated. An action level is the population size which requires remedial action for human health, economic, or aesthetic reasons.
4. **Prevention:** Preventive measures must be incorporated into the existing structures and designs for new structures. Prevention is and should be the primary means of pest control in an IPM program.
5. **Tactics Criteria:** Under IPM, chemicals should be used only as a last resort only, but when used, the least toxic materials should be chosen, and applied to minimize exposure to humans and all non-target organisms.
6. **Evaluation:** A regular evaluation program is essential to determine the success of the pest management strategies.

Lemon butterfly: *Papilio demoleus* Linn; Papilionidae: Lepidoptera

It attacks Citrus spp. unlike most swallow tail butterflies it does not have a prominent tail. The butterfly is a pest and invasive species from the Old World which has spread to the Caribbean and Central America. In India it has become a pest of major importance overtime. The larvae feed on leaves eating from the edge right up to midrib. Seedlings and young plants are completely defoliated. Depending upon season a generation takes about weeks to four months. There are 5-6 overlapping generations a year. It overwinters as pupa.

Economic Importance: It causes severe damage to citrus particularly in nurseries.

Marks of Identification

Butterfly: Have yellow and black markings on wings.

Larva: Green colour and measures 38 mm, when disturbed they protrude two fleshy horns from the neck, known as "Osmaterium".

Host Plants: All citrus species and other plants like bael, ber, curry leaf plant, *bawachi* etc.

Nature of Damage: Caterpillars feed on tender leaves right up to the midrib and defoliate the plants in case of severe infestation. Citrus butterfly is a pest of nurseries and young plantations.

Caterpillar feeds on foliage causing defoliation. At times young plants are completely defoliated. Most destructive stage is larva. Young larval stage looks like bird excreta (Nath and Deka, 2019) [5].

Life History

Eggs: 70 to 180, singly on tender leaves, Incubation periods: 3 to 7 days. Larva: Larval periods 2 weeks. Pre-pupal periods: 10 to 15 days, may extend up to 2 to 3 months in winter. Pupa: Pupation on plant, remain attached by silken threads. Adult periods: Male: 3 to 4 days, Female: 7 to 8 days. Number of generations: 4 generation per year.

Management Practices

Collection of infested leaves and destroying by burning or burying under the soil. Hand-picking and destruction of the various stages of the butterflies, Severe infestations can be controlled by spraying leaves with Malathion 57 EC or Dimethoate 40 EC at the rate of 2.0 ml/litre of water.

Release Parasitoids: *Trichogramma evanescens*,*Telenomus* spp., (egg), *Brachymeria* sp (larval), *Pterolus* sp. (pupal)

Leaf miner: *Phyllocnistis citrella* S.; Phyllocnistidae: Lepidoptera.

Economic Importance

Most destructive pest, active in monsoon, maximum infestation noticed in seedling stage. The pest is suspected to be responsible for the spread of bacterial infection causing citrus canker.

Marks of Identification

Moths: Small, silver white colour, forewings with brown stripe and prominent black spot near the tip.

Caterpillar: Yellow in colour with brown mandibles.

Host Plants: All citrus species, bael.

Nature of Damage

On hatching larva feed on leaf tissues between upper and lower surfaces of leaves making glistering zigzag tunnels. The leaves turn pale, curl and finally dry. Besides, mined leaves may get bacterial infection which leads to citrus canker. Mostly important in nursery and young orchard. Larval stage is more destructive. Newly emerged larva mines the under surface of the leaf in a zigzag way.

Appearance of silvery serpentine mines on the underside of leaf which leads to wrinkling and curling up. Leaf miner attacks helps in spreading mealy bug infestation and predisposes to Canker infection (Nath and Deka, 2019) [5].

Life History

Eggs: singly on underside of leaves (36 to 76 eggs), Incubation periods: 3 to 6 days. Larva: 1 to 2 weeks. Pre-pupal periods: 1 to 4 weeks. Pupa: Pupation inside the larval mines of leaves, Life cycle is completed in 2 to 6 weeks. No. of generations: 9 to 13 generation per year.

Management Practices

Removal of infested leaves/twigs and their proper disposal. For effective control, prune heavily the affected parts during winter and burn the same. Plants with new flushes of leaves should be sprayed with Dimethoate 40 EC or Carbosulfan 20 EC or Malathion 57 EC @ 2.0 ml/litre of water. A second spraying should be given after 15 days of the first spraying. Spray 0.05% triazophos or quinalphos 0.01% or NSKE 5% as soon as attack is noticed.

Citrus psylla: *Diaphorina citri* K.; Psyllidae: Hemiptera

Citrus psylla has become a very serious pest in all citrus growing areas of India. It attacks all parts of the plant above ground. It is a known vector of the disease 'citrus greening'. The insect excretes honey which accumulates on the plant leaves and twigs. Sooty molds develop on the honey and the plant becomes black interfering with photosynthesis of the plant thus indirectly affecting plant yield. Insect feeds on plant sap and under high populations plant start dying.

Economic Importance: Most destructive of all pests of citrus, Also transmit "Greening melody", a micoplasma disease in citrus.

Marks of Identification: Adults: Small, dark brown in colour. Wings are folded like roof over body. Nymphs are spherical, pinkish and sedentary.

Host Plants: Citrus and other plants belonging to Rutaceae and curry leaf plant.

Nature of Damage: Both nymph and adult suck the cell sap from tender leaves, shoot and buds, which as a result curl, dry up and ultimately drop down. Complete crop failure is reported in case

of severe infestation. Peak period for multiplication is in May. Both nymph and adult sucks the cell sap from newly emerged leaves, tender shoots and flowers causing curling of leaves and defoliation leading to deblossoming and dieback. Secretes whitish crystalline honeydew which attracts the growth of fungus, adversely affecting the photosynthesis. Psylla is also known to inject toxin in plant due to which die-back of shoot occurs. It acts as vector of citrus greening virus disease (Nath and Deka, 2019) [5].

Life History
About 800 eggs are laid in leaf axis and hatch in 4-6 days in summer and 22 days in winter. Nymph develops in 2 weeks in summer and 3-4 weeks in winter. Adult longevity may extend over 6 months. The developmental period from egg to adult takes 15 days in summer and 47 days in winter. There are 9 generations in a year. Pests overwinter in adult stage.

Management Practices: Monitoring using yellow sticky trap. Chemical control using dimethoate @ 1.25 ml or imidachloprid @ 0.3 ml or quinalphos @ 1.0 ml or acephate @ 1g or thiometan 0.8 ml at bud burst stage. Second spray should follow after 10-15 days. Extracts of botanicals like *Vitex nigundo*, *Acorus calamus*, etc. can also be used. Biological control: Predators like *Mallada boninensis* Okamoto and *Cheilomenes sexmaculata* (Fabricius) and host specific parasitoid, *Tamarixia radiata* (Waterston) are effective in bringing down the psylla population.

White fly and Black fly: *Dialeurodes citri* A & *Aleurocanthus woglumi* A Aleyrodidae: Hemiptera.
Economic Importance: White fly and black fly are of common occurrence and destructive pest of citrus. It causes '*Kolshi'* in citrus and reduces plant vigour.

Marks of Identification
White fly: Adults: Minute insect (1 mm) with yellowish body and red eyes. Wings white or greyish, covered with mealy secretions. Nymphs and pupae: Are oval shaped, scale like and brownish with marginal bristle like fringes.

Black fly: Smaller in size and black in colour.

Host Plants: Citrus, cotton, castor, banana, coffee, mango and pomegranate etc.

Nature of Damage
Nymphs and adults suck the cell sap from leaves, as a result leaves wither and turn brownish. Nymphs excrete honey dew on which black sooty mould develops. The blackish coating commonly called "*Kolshi*". Fruit setting is adversely affected in case of severe infestation. The cell sap is suck from the leaves leading to leaf curling, leaves fall off immaturely. Honey dew secretion leads to sooty mould fungus. Leaf turns to black in colour and affects photosynthetic activity of the leaves. Affected trees produce few blossoms which develop into insipid fruits (Nath and Deka, 2019) [5].

Life History
A female lays about 200 eggs. Eggs are laid on underside of leaves and hatch in 10 days. Nymph develops in 3-10 weeks and forms pseudo pupa (quescent stage) on underside of leaves, pupal period is 16-22 weeks. The total life cycle is completed in 20-33 weeks. Two generations are completed in a year.

Management Practices
1) Avoid close planting and water logging. 2) Clip off and destroy infested leaves. 3) Sprays 0.05 % profenofos or dimethoate or quinalphos for second and third instar nymphs. 4) Spray 0.1% dimethoate or quinalphos for the control of last instar.

Parasitoids: *Encarsia formosa, Eretmocerus* spp.(Pupal)

Predators: *Chrysoperla zastrowi sillemi*,coccinellids, spiders

Fruit sucking moth: *Eudocima (Othreis) fullonica* C.; *Eudocima (Othreis) materna* L.; *Achoea janata* L.;
Noctuidae: Lepidoptera.

Economic Importance: Moths puncture the fruits and causes fruit rot.

Marks of Identification

Moth: Large sized, forewings grey or brown. Hind wings orange or yellow with black spot in the center and marginal dark bands. Kideny shaped black spots in *E. fullonica* and round black spots in *E. materna.* Larva: Typical semilooper and have stout appearance, full grown larva 5 cm long, velvety dark brown colour.

Host Plants: Larva feeds on leaves of wild creepers like *gulvel* and *wasanvel* and moth feeds on fruits of citrus, mango, pomegranate, grape, cashewnut etc.

Nature of Damage
Moths are nocturnal and seen flying in orchards after dusk. Moths puncture the ripening fruits and suck the juice. Bacterial infection to the infested fruit causes rotting.

Life History
Eggs: 300, on leaves of wild creepers. Incubation periods: 3 to 4 days. Larva: larval periods: 20 days. Pupa: Pupation in soil, P. P: 9 days. Life cycle is completed in 4 to 6 weeks.

Management Practices
1) Eradication of host plants viz. *gulvel* and *wasanvel*, etc. 2) Collection and destruction of moths at night. 3) Poison baiting (20 ml malathion 50 EC + 200 g jaggary + 2 lit. water). 4) Bagging of matured fruits with paper or cloth bags. 5) Quick removal and disposal of fallen fruits.

Bark eating caterpillar Or Bark borer: (i) *Indarbela quadrinotata* W.; (ii) *I. tetraonis* M.;Inderbellidae : Lepidoptera.
Economic Importance: It causes severe damage to citrus in Maharashtra State.

Marks of Identification: Moth: Short, stout, ashy grey in colour.

Larva: Dirty brown in colour, slender and measures 5 to 6 cm.

Host Plants: Citrus, mango, ber, guava, pomegranate, jamun, aonla etc.

Nature of Damage

Larvae bore into wood making short tunnels in which they hide during the day and come out at night to feed on the bark. As a result of feeding on bark the sap conducting tissues are damaged which interrupt the translocation of cell sap. Frass and silken threads over the bark surface form the webbing. The growth and fruit setting is adversely affected.

Withering of branches. Infest bark of young and matured citrus plant.

Larvae make tunnel at the joints of trunk or branches and feed on the bark during night. Heavy infestation leads to slowly drying of plant due to nutrient deficiency. Attacked tree gradually declines (Nath and Deka, 2019) [5].

Life History

Eggs: 350, on bark in May-June. Incubation periods: 8 to 11 days. Larva: larval periods 8-10 months till about 3rd week of April. Pupa: Pupation inside larval tunnel, P.P.: 21-41 days. Moth longevity: 3 days. No. of generation: 1 generation per year.

Management Practices:

1) Remove ribbon like silken webs from affected branches/trunks, detect the larval tunnel and insert iron spike in it to kill the larva. 2) Inject CS_2 or borer solution (2 parts CS_2 + 1 part chloroform + 1 part creosote oil) in borer-holes and plaster the holes with mud or insert into the borer holes insecticide – soaked cotton plugs and plaster the holes with mud. The insecticides for per litre of water are 4g carbaryl 50 WP or 2 ml dichlorvos 100 EC or 3 ml. profenofos 50 EC, petrol, kerosene. These chemicals should be applied after removing webbings. 3) Spot application (spraying) of profenofos or dichlorvos or quinalphos at 0.08% or fenvalerate 0.04%.

Aphids: *Toxoptera aurantii* F., *T. citricidus* K.; Aphididae: Hemiptera.

Nature of Damage:

Both nymphs and adults suck cell sap from leaves and tender shoots.

This impairs the vitality of the tree and cause severe curling and deformation of young leaves resulting into stunted growth of leaves and twigs. Feeding also results premature falling of fruits and reduces their quality, which fetches poor price in the market. Besides, it secretes honeydew that attracts black sooty mould (*Capnodium* sp.) fungus, affecting photosynthesis. Also these aphids are the principal virus vector of Triesteza virus.

Host Plants: Citrus, group.

Life History: Reproduction is parthenogenetic and viviparous. A female reproduce 1 to 16 nymphs per day and lays more than 100 in a life period of 12 to 33 days. The nymphs moult four times and become adult, the period varying from 4 to 16 days depending upon temperature and food conditions. A generation normally takes only 6 to 8 days but at 15° C it takes as long as 3 weeks and at 25° C only 6 days. There are about 12 generations in a year.

Management Practices: Conserve natural enemies. Spray with 0.05% dimethoate, or monocrotophos or methyl demeton as soon as infestation noticed.

Integrated Pest Management practices for citrus (Nath and Deka, 2019) [5]

- Conditions that lead to stress on plants should be avoided such as close planting and water logging.
- Good orchard sanitation and removal of weed.
- The affected plant parts should be pruned and destroyed.
- Excessive use of nitrogenous fertilizer and irrigation should be avoided.
- Need base application of insecticides) for management of insect pests based on ETL.
- Use and conservation of predators/parasitoids.
- Field release of predatory ladybird beetle, *Cryptoleamus montrouzieri* @ 10 beetles/plant and inoculative release of exotic parasite, *Leptomastrix dactylopii* is very effective.
- For management of bark eating caterpillar, citrus trunk borer and many other diseases, application of Bordeaux paste during March-April and September-October on the tree trunk up to the height of 1m is very effective.

Conclusion

Citrus is the most important horticultural crop in India. So, many insect pests causes economic loss. The major insect pests are Bark eating caterpillar, Fruit sucking moth, White fly, Black fly, Citrus psylla and Lemon butterfly. Their populations could be controlled by the following package and practices such as use of high yielding varieties, proper plantation management (including clean cultivation by pruning trees time to time and removal of weeds, which serve as alternate hosts of pest inoculate during off season), providing fertilizers supplement, efficient irrigation system, and integrated pest and disease management. Different type of pesticides available in market to uses the judicial in the farmer field. Moreover, the government takes the different citrus more grower programme to increases the production.

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