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Manual on transmission of plant viruses and phytoplasmas by insect vectors

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Foreword

Plant viruses and phytoplasmas are obligate parasites and important group of pathogens causing immense economic loss to Indian agriculture. As they generally move horizontally through vectors particularly insects, it is important to study virus-vector relationship and mode of transmission for their effective management. This manual on transmission of plant viruses and phytoplasmas by insect vectors has been brought out very timely when we are witnessing more and more numbers of plant viruses and phytoplasmas in our agriculture system. There is a need to study the horizontal transmission of these plant viruses and phytoplasmas by insect vectors as well as their biological associations with insect vectors. I congratulate Dr. Amalendu Ghosh, Dr. G.P. Rao and Dr. V.K. Baranwal who have made sincere efforts to bring out this publication. I am sure that the information included in this manual will be highly useful for plant protection researchers to understand the transmission of plant viruses and phytoplasmas and develop strategies for their management.

(Rashmi Aggarwal)

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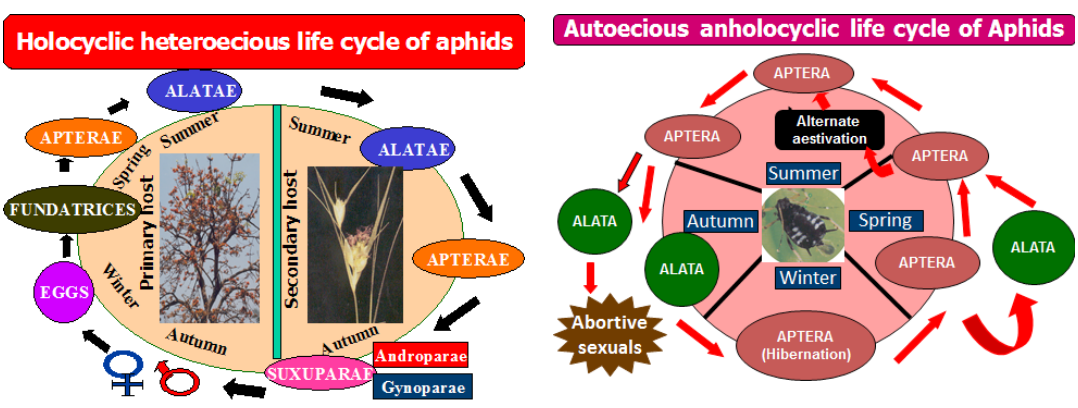
Aphids (Hemiptera: Aphididae) include over 5000 extant species. Aphids are also known as green fly, black fly, ant cow or plant louse. They are soft bodied, small, sap sucking insects with piercing sucking mouthparts which help them to feed on the plant sap. They are evolved with the siphuncular pore and most of the species have a pair of cornicles on the abdomen. Aphids usually occur in colonies on the undersides of the tender terminal growth protected from the sunlight and higher temperature.

The life cycle of aphids is very complex; the mode of reproduction is greatly influenced by the bio-ecological factors. Different species depict multifarious life cycle pattern in the different bio-geographical locations. They may alternate between sexual or asexual reproduction (holocyclic) or all young ones are produced by parthogenesis only (anholocyclic). However, some species can also have both holocyclic and anholocyclic population. Some species show different patterns in temperate and tropic regions. Sexual morphs are produced mainly in the autumn and the oviparous females lay the overwintering eggs after mating. In the following year, when plants resume growth, the eggs hatch and a series of parthenogenetic generations develop. Many species have host alternating behaviour (heteroecious) between a woody tree and an herbaceous plant while others feed on the same host plant throughout the life (autoecious).



Two types of lifecycles of aphids (Ghosh et al. 2017)

Aphids infest a large number of agriculturally important crops. Plants under Asteridae have more than 800 specific aphids followed by Rosidae, Hamamelidae, Liliatae and

Chapter 4

Protocol for rearing of thrips and tospovirus transmission

Introduction

Thrips (Thysanopetra: Thripidae) are small (1-2 mm), slender, fringed-winged insects. Thunder flies, thunder bugs, corn flies, storm bugs, corn lice, physopods, and freckle bugs are the common names used for thrips. They feed on a variety of plants causing considerable economic losses to vegetables, legumes and ornamental plants. Till date, nearly 7,700 thrips species have been reported, out of which less than 1% are agricultural pests. Some of the thrips species are predators of other soft-bodied insects, mites, scales, aphids, and other phytophagous-thrips species. They are mainly yellow, orange, black, brown or whitish-yellow in color. Thrips generally crawl leisurely but fast when disturbed. The head is embedded with two compound eyes and three ocelli and is quadrangular in shape. Antennae are filiform, 6-9 segmented with short, simple or forked sensory organs. Prothorax is freely movable and broad but the mesothorax and metathorax are fused together. Legs are with one to two segmented tarsi and a pair of weak claws. The abdomen is 11 segments and tapering. The first and last segments are reduced. The female reproductive organ is saw like and curved downwards. In case of male, the apex of abdomen is bluntly rounded. The life history of an adult thrips comprises of eggs, first and second instar larvae, pre-pupa, pupa, and adult. Eggs are generally reniform and translucent in color. The eggs turn to yellowish-orange at maturation. The larvae are similar to adults but do not have wing pads and have lesser segments in antennae. The first instar larvae molt into second instar in 24-36 h. The second instar develops into pre-pupa within 4-5 days depending on temperature. Both pre-pupa and pupa have wing-pads but lack protrusible vesicle on the tarsi of legs. The life span of adult female ranges from 4-5 weeks. The adult female lays eggs under the upper epidermal layer of plant parts by making a slit with their ovipositor and can lay nearly 50-200 eggs in its life-time. Thrips have haplodiploid mode of reproduction and are capable of parthenogenesis. Some species show arrhenotoky (males are produced) and others follow thelytoky (produced female offspring).

Unlike other hemipteran insects, thrips have very characteristic mouthparts. The primary feeding structures are confined within a cone formed by clypeus, labrum, and labium. The mouthparts include one elongate hypopharynx, two maxillay stylets and one mandibular stylets, supported by cibarial and salivary pumps. The mouthparts are asymmetrical as the right mandible is absent or vestigial. The food canal is formed by the maxillary stylets and no separate salivary canal is present in thrips. The saliva is directly released into the esophagus.

Chapter 5

Rearing iso-female line of sweet potato whitefly (*Bemisia tabaci*) for *Begomovirus* transmission

Introduction

Whitefly, *Bemisia tabaci* Gennadius (Hemiptera: Aleyrodidae) ranks 14th among the 100 worst invasive species in the world. Among the 1556 known whitefly species under 161 genera, *B. tabaci* is agriculturally most important due to its ability to infest more than 1000 plant species including food, fiber and ornamental crops. Heavy infestations of whitefly cause chlorotic leaf spots and formation of sooty mold due to the secretion of honeydew. Besides inflicting direct damage to the crops, it can transmit more than 300 plant pathogenic viruses. Major groups of plant viruses transmitted by whitefly belong to genus *Begomovirus, Carlavirus*, *Crinivirus*, *Ipomovirus*, *Torradovirus*. Adult female lays oval to elliptical whitish eggs, anchored by a pedicel on adaxial surface of leaf. These eggs turn brown as they mature. The egg hatching takes place after 5-9 days depending on host species, temperature and humidity. The first instar nymph known as crawler is oval and flat, and mobile. The crawlers search suitable feeding location in the lower leaf surface. Once the crawler settles for feeding, it loses its legs and becomes sessile. The first three instars last for 2-4 days each. The fourth nymphal stage is also known as 'puparium', lasts about 6 days depending on temperature. The adult emerges through a "T"-shaped rupture in the skin of the puparium and copulation begins 12-20 h after emergence. The female could live up to 60 days whereas males live shorter. *B. tabaci* produces eleven to fifteen generations within one year. Both sexual and asexual reproduction are observed in *B. tabaci*. However, apparently all males are parthenogenetically produced by arrhenotoky. Mouthparts of adult *B. tabaci* are composed of the labrum, labium, and stylets. The stylet bundle is composed of two maxillary stylets and two mandibular stylets. Whitefly feeds on the phloem sap by inserting its stylets.

There exists a large genetic divergence within *B. tabaci* individuals indicating existence of a species complex of *B. tabaci* which are morphologically identical. The divergence within *B. tabaci* has been explained as race, biotype, haplotype, cryptic species, phylo-geographic clade, genetic species etc. There are porous species boundaries within individuals which may be in a juvenile stage of speciation. As of now, *B. tabaci* is considered to be a large cryptic species complex composed of morphologically indistinct individuals from 39 species.