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A review: Important mite pests associated with horticultural fruits crops

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Abstract
No need to emphasise the importance of horticultural products, particularly fruit crops, to the Indian economy. Numerous fruits, including mango, litchi, citrus, guava, sapota, and pomegranate, are grown commercially and on a huge scale throughout India. Other fruits include apple and pear, peach, plum, apricot, and cherry, as well as walnut, pecan, hazelnut, and pistachio nuts. The majority of these crops, with an annual production of 2471 thousand tonnes and an average productivity of 5.14 t/ha, have greatly improved farmers' economies (Indian Horticulture Database, 2010). Acarina (Phytophagous Mites) are a global group with a wide host range, and they are one of many pests that wreak havoc on these crops (insects such as scale, woolly aphid, mites, thrips, and rodents and mite, among others). These phytophagous mites cause biotic stress to their host plant and negatively affect the marketable produce, costing growers money. Integrated mite management, which includes cultural control, the use of mite and insect predators, botanicals/biopesticides, and the management of fungi, bacteria, and viruses, is one environmentally friendly strategy that can be used to keep these mites under control in a variety of horticultural crops.

Keywords: Fruit crops, phytophagous mites, integrated pest management

Introduction
The 480 thousand hectares of temperate tree fruit and nut crops in India produced 2471 thousand tonnes (t) with an average yield of 5.14 t/ [26] Apple, pear, peach, plum, apricot, cherry, almond, and walnut are the main fruits that grow in temperate climates. Despite the fact that many insect pests are to blame for the majority of production losses, several mites also pose a significant threat to temperate fruit crops (Verma *et al.*, 2010) [1]. One of the most significant pests that degrade produce quality and lower it below international quality requirements are mites. With their very distinct physical makeup and eating habits, these tiny members of the arachnid class are more similar to spiders and ticks than to any other insects, which typically have eight legs and lack both antennae and body segments. The typical method of feeding for many phytophagous mites is to stab their mouthparts into their host plants and sucking out the sap. Some mites harm plants by producing web-like structures; curled leaves; speckled foliage; mottled leaves; and little dots (stippling) on the tissue of the leaves. Other mites produce growth deformities like galls [2]. Puncturing and feeding plants may result in a deterioration in their health, sporadic leaf loss, and very infrequently, plant death. In this paper, we focus on the significant mite pests of various temperate fruit crops and their management strategies in order to achieve optimal production of horticulture fruit crops and compete at global level in terms of productivity. Knowledge about mites that cause quality deterioration, and in turn up shoot major export standard problems making great losses at global trade, provides a need to study their biology, bionomics, and management.

Phytophagous mites
Even though there has been a lot of research done on mites over the years, many of them are still unknown, or their significance in the environment is still unknown. Because they consume plants or spread disease to crops, mites pose as pests in agriculture. Honey bees, which are vital to the pollination of many crops, are one of the many organisms that are attacked by mites in addition to a wide variety of crops [3], livestock (Sheep, poultry, cattle, swine), either by directly feeding on them or by transmitting diseases to them and also postharvest storage of crops. Some mite species are helpful because they function as potent natural enemies of some phytophagous mites, so not all the mites that were reported are pests. Some mite species, such

as those in the Oribatida or Cryptostigmata, are crucial in the breakdown of organic matter and aid in the cycling of nutrients in the soil. In this essay, we mostly concentrate on mites that are harmful to fruit crops. In India, there are roughly 12 different types of mites that were regarded as serious pests [4, 5]. Families including the spider mite (Tetranychidae), false spider mite (Tenuipalpidae), gall mite (Eriophyidae) and Tarsonemidae are home to the majority of phytophagous mites.

Tetranychidae Family

The most significant phytophagous mite pests of agriculture worldwide are members of the Tetranychidae (Actinedida or Prostigmata) family, often known as "Spider Mites," which prey on food crops, trees and ornamentals [14, 19, 2, 24]. Significant productivity losses and even agricultural plant mortality can result from a spider mite infestation. There are reports of 1250 mite species feeding on 3877 plant species, however only 100 species are thought to be economically significant [6]. The total number of species is currently unknown, and given that the taxonomy of this group is still in flux, some species may likely include cryptic species. The following very few species are regarded as substantial pests of significant crops: *Tetranychus urticae*, *T. cinnabarinus*, *T. pacificus*, *T. kanzawai*, *Panonychus ulmi*, *P. citri*, *Oligonychus punicae*, *O. coffeae* and *Eutetranychus orientalis*. The most infamous spider mite is the two-spotted kind, *T. urticae*, which is found all over the world.

Life cycle

Although spider mites typically prefer to feed on the lower leaf surface, they will readily infest the top leaf surface when populations are high. Spider mites' life cycles are significantly influenced by temperature; at 30 °C, they are finished in 8-12 days, whereas at 20 °C, they take about 17 days. These organisms overwinter in warmer climates on various weed hosts, although females can also do so while in the diapause stage in plant debris. Each day, females lay 5 to 6 eggs, for a total of 60 to 100 eggs per female. When the temperature is right, eggs hatch in 3 to 6 days, larvae and nymphs grow fully in 4 to 9 days, and females experience a pre-ovulatory stage of 1 to 2 days. About 30 days are lived by adults.

Loss to the crop Spider mites are typically found on the lower surface of the foliage, where they pierce plant cells and ingest the contents of the cells. However, if their population is high enough, they may eventually cover the entire leaf surface. As a result, the affected leaves take on a speckled look and develop small clumps of necrotic tissues. With persistent, dense infestations, symptoms include desiccation, leaf deformation, wilting, and abscission appear. Stunted plants and decreased yields are the results of photosynthesis disruption.

Eriophyoidea

After the Tetranychidae, Eriophyoidea mites, often known as "gall mites, blister mites, and rust mites," are thought to be the second most significant agricultural mite pests. These mites have an unusual interaction with their host plants, causing morphological deformities such as obvious galls. Eriophyid mites differ from other mite species in that they have an elongated, worm-like body and only two pairs of legs as opposed to four pairs of legs and a spider-like body structure. The most obvious signs that eriophyid mites are present are the galls or other plant deformities including rusting, leaf folding, or blistering because of the mites' small size.

Life history

Eriophyid mites have a relatively straightforward life cycle, developing through four growth stages during the spring and summer: egg, first nymph, second nymph, and adult, which is also the overwintering stage. However, some eriophyid mites have a more complicated life cycle that alternates between a female-only generation and a male-female generation. These adaptations are supposed to be based on the seasonal variations of the host material for eriophyid that feed on deciduous plants. Deutogynes are overwintering, female-only mites, and protogynes are females linked with female-male generations. Even within the same species, these protogynes and deutogynes can vary greatly in size and shape, making identification challenging. Eriophyid mites move between hosts through hitchhiking on insects or birds and air currents.

Damage symptom

Eriophyid mites have a unique relationship with their host plant and are typically located on the fleshy tissues of the host plant. When mites inject their saliva, galls form, acting as the mites' unique feeding grounds. These galls, which can be of various types, all develop on the host plant's tender parts. These include the bladder, bead, finger, and pouch galls, which are frequently covered in hairs, or erinea, which are plant hair growths brought on by mites. In addition to having distinctive hairy or fuzzy pads on their leaf surfaces or other plant components, plants harbouring eriophyid-induced erinea frequently feature colourful erinea. Eriophyid mites can also cause excessive bud formation and twig elongation because of the components in their saliva that control growth. Eriophyids can also result in "giant buds," which are enlarged buds. They can also affect a plant's typical appearance by causing blisters on the leaf surface or rolling leaf edges [7].

Tenuipalpidae

The Tenuipalpidae family of mites often goes by the names "flat mites" and "fake spider mites" due to their resemblance to spider mites (family Tetranychidae) and their unusually flattened bodies in compared to other mites. The majority of Tenuipalpus live in tropical or subtropical climates, and they are all plant-eating animals [18, 19, 20, 21]. Gerson [21] documented about 30 genera with 900 recognised species, but it's possible that many more tropical and subtropical plant species are still uncovered. Similar to Childers [22], who discovered that 928 plant species in 513 genera and 139 families are attacked by 3 species (*Brevipalpus californicus*, *B. obovatus* and *B. phoenicis*). The majority of plant species are harmed by the two genera Brevipalpus and Tenuipalpus.

Life cycle

Tenuipalpidae mites are similar in size to spider mites and typically have a brick-red to yellow body colour. The same developmental phases as spider mites, including egg, larva, proton mph, deuteron mph, and adult, are also present in false spider mites. On the underside of leaves, they are located along the veins. The dorsal surface of these flattened, egg-shaped mites has a pattern resembling a web. The eggs, which are crimson in colour and elliptical in shape, are placed in hundreds per cluster along the mid vein or in the leaf fold.

Damage symptoms

False spider mites (Tenuipalpidae) harm plants by leaving behind a scabby discoloration on the underside of leaf blades and collapsible patches where they have fed. This damage frequently results in premature ageing and misshapen plants, but these mites don't make webs. *Brevipalpus phoenicis*, the false spider mite, is also known to spread plant viruses and feeds on a variety of fruit crops, including citrus, papaya, and pomegranates [8].

Tarsonemidae

Species of the family Tarsonemidae (Prostigmata or Actinedida), also known as "white mites" or "thread footed mites," have a wide range of dietary preferences. Some species feed on algae, fungi, and plants, while others are parasitic mites [19, 23]. Tarsonemidae has three subfamilies and 530 species spread across 40 genera. Few species of these mites are found in the Nearctic and Palearctic regions, despite the fact that the majority of their range is restricted to the tropical and subtropical climates. The Tarsonemidae and Pseudo Tarsonemidae super families contain the majority of the Phytophagous Tarsonemidae mites [24]. The majority of species in this family are harmless and feed on fungus and other organic debris. Important plant parasites include those belonging to the genera *Polyphagotarsonemus* (*P. latus* (Banks), the broad mite, tropical mite, and tea mite), *Hemitarsonemus* (on ferns), *Phytonemus* (*P. pallidus* (Banks), the cyclamen mite), and *Steneotarsonemus* (e.g., *S. ananas* (Tryon), on pineapple, *S. bancrofti* (*Steneotarsonemus* species) generally cause damage in conjunction with fungi infections. Other pests include those that harm bees, forest trees, and the mushroom industry in addition to the plant parasite *Tarsonemus*.

Life cycle

With just two active life stages-nymphs and adults-the family Tarsonemidae completes its life cycle quickly, often in less than a week. The nymphs' feeding cycle is rather brief, and they immediately moult into adults. Arrhenotoky is the method of reproduction, and the sex ratio varies.

Damage symptoms

These mites feed mostly on the underside of leaves close to the stem, causing the leaves to curl and turn dark. Brown discolouration results from the tips of damaged plants becoming deformed, with twisted leaves and corky forms. Damage from broad mites (*Polyphagotarsonemus latus*) is typically identified by the development of dark brown borders at the base of young leaves. Mild infestations may cause a network of brown stripes to form on leaves, but severe infestations cause this network to become dense and result in the full loss of green tissues, as well as the frequent appearance of distorted corky patches that cause malformed leaves. Fruits become misshaped and crack open where distorted corky patches are present. Flowers become brown. Relatively small populations have the potential to do significant harm [9]. The bottom leaves of a plant frequently persist. The undersides of young leaves are where broad mites (*P. latus*) are most commonly seen. Even weeks after the mites have been removed, symptoms are still present.

Integrated management of mites

The integrated management of mites idea seeks to reduce the use of pesticides while controlling pest populations through the application of environmentally benign techniques like as cultural techniques, biological techniques, resistant cultivars, and acaricides with minimal after-effects. The first and most important method of integrated mite management is cultural methods, which entails ploughing, clearing fields of stubbles after harvesting crops, fallowing fields, rotating with a different crop, and occasionally properly cleaning equipment used in all of these operations before using it in an un-infested field. Biological approaches offer an economical and environmentally sustainable way to control pests, either alone or as part of IPM [10]. Phytoseiid mites are a particular subgroup of mites that are widely used as bioagents to control phytophagous mites. Gupta [11] of India listed 139 phytoseidae mite species along with their taxonomic groups.

However, there are also predatory species in the families Stigmaeidae, Erythraeidae, Typeid, Anystidae, Cheyletidae, and Hemisarcoptidae [12, 13, 5]. It is advised to use predatory mites as a bio-control agent in mite pest management programmes and to adopt an IPM strategy:

i) By utilizing naturally and locally occurring predacious mites,
ii) By releasing predatory mites and
iii) By utilizing pesticide resistant strains of predacious mites.

In 1920, sulphur is typically used to combat mites [14]. The so-called dicofol, which is widely employed in Indian tea gardens, was just created in 1952. This composition is offered commercially under the names hilfol, kelthane, etc. Acaricides that were developed after the 1960s, such as mores in, cyhexatin (Plectrum), and chlordimeform (Galectin), are not commonly used in India. Acaricides such phosphate (Zolone), dinocap (Karathane), ethion (Phosmite), and tetrad form (Tedion) are similarly not very well-liked or only occasionally utilised. In India, insecticides from the class of compounds containing organophosphorus are frequently used to control mite populations. Dimeton (Metasystox), Disulfoton, Thiodemeton (Disyston), Quinalphos (Ekalux), Thiometon (Ekatin), Formothion (Anthio), Phosphamidon (Dimecron), Carbaryl (Sevin), and Dimethoate are some of the insecticides in this group (Roger). Insect pest control, particularly the management of spider mites, has proven to be successful when temporary environmental changes are made. In general, substantially lower oxygen levels and increasing carbon dioxide concentrations at high temperatures can cause death at all embryonic stages. However, it has been demonstrated that slight CO_2 enrichment actually increases mite reproduction [15]. In one investigation, 0.4 per cent O_2 and 20 per cent CO_2 were found to have LT99 (time to 99 per cent mortality) values of 113 h at 20 °C and 15.5h at 40 °C [16]. Another study found that utilising 60 per cent CO_2 and 20 per cent O_2 at 30 °C for 16 hours resulted in 100 per cent death of different stages of the two spotted spider mite [17]. Advantages would include potential ease of application and reduced possibility for resistance development compared to miticides, while disadvantages might include plant sensitivity to environmental conditions, application feasibility, and human safety.

Conclusion

In recent years, phytophagous mites have become more economically significant in the production of horticulture commodities, particularly fruit crops, as they may be damaging to harvests if not appropriately controlled and can lower the quality standards in both international and domestic trade. The development of efficient control strategies is aided by knowledge of their biology, incidence, and mode of damage. These mites, which can cause problems with resistance, the emergence of new strains, and pest recurrence, were the primary targets of the great majority of acaricides, particularly in fruit and vegetables. The mite ACC as well as electron transport at complex II and complex III are the targets of more recently created drugs with novel modes of action. The greatest method for establishing long-term mite control is to use acaricides sparingly in conjunction with IPM.

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