Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
JEZS 2019; 7(4): 1378-1384

Received: 01-05-2019
Accepted: 05-06-2019

Manju Devi
Dr. Yashwant Singh Parmar University of Horticulture and Forestry Nauni, Solan, Himachal Pradesh, India

Nalini Challa
Dr. Yashwant Singh Parmar University of Horticulture and Forestry Nauni, Solan, Himachal Pradesh, India

Gaikwad Mahesh
Dr. Yashwant Singh Parmar University of Horticulture and Forestry Nauni, Solan, Himachal Pradesh, India

Correspondence
Manju Devi
Dr. Yashwant Singh Parmar University of Horticulture and Forestry Nauni, Solan, Himachal Pradesh, India

Important mite pests of temperate and sub-tropical crops: A review

Manju Devi, Nalini Challa and Gaikwad Mahesh

Abstract
Role of horticultural produce especially fruit crops on Indian economy needs no emphasis. Different temperate and sub-tropical fruits namely apple and pear, peach, plum, apricot and cherry, walnut, pecan nut, hazelnut and pistachio nut, mango, litchi, citrus, guava, sapota and pomegranate are commercial and cultivated on large scale all over India. Majority of these crops have contributed significantly in uplifting the economy of farmers with an annual production 2471 thousand tones (t) and average productivity of 5.14 t/ha (Indian Horticulture Database, 2010). Among multiple pests that ravage these crops (Insects viz. scale, woolly aphid, mites, thrips, and rodents and mite etc.), Acarina (Phytophagous mites) is a cosmopolitan group with wide host range, these phytophagous mites cause biotic stress to its host plant and adversely affect the marketable produce causing losses to growers. Integrated mite management is one eco-friendly measure that can be implemented to keep these mites under control, which includes cultural control, use of mite and insect predators, botanicals/bio-pesticides, fungi, bacteria and virus play an important role in managing mite population in various horticultural crops.

Keywords: Phytophagous mites, fruit crops, integrated pest management

Introduction
The temperate tree fruit and nut crops of India were grown over an area of 480 thousand hectares with a production of 2471 thousand tones (t) and average productivity of 5.14 t/. [26] The major temperate fruits are apple, pear, peach, plum, apricot, cherry, almond, and walnut. However many insect pests are responsible for the major production losses, a part from the insect pests many mites also pose serious problem to temperate fruit crops. (Verma *et al*, 2010) [1]. Mites pose one of the most important pests that deteriorate the quality of produce which affects the international quality standards. These miniature creatures of the class arachnid with their very unique physical structure and feeding habits make a close resemblance to spiders and ticks than to any other insects which characteristically possess eight legs and lack both antennae and body segments. Many phytophagous mites usually feed by throbbing mouthparts into their host plants and sucking out the plant's sap. Certain mites cause damage to the plant causing web-like structures; Curling of leaves, speckled foliage, mottling of leaves and also in the form of small dots (Stippling) on the leaf tissue, and some cause growth distortions such as galls.[2] Puncturing and feeding may lead to decline in the plants health, cause occasional leaf drop and rarely causing plant death. In order to obtain optimal production of horticulture fruits crops and compete at global level in terms of productivity, knowledge about mites which cause quality deterioration, and in turn upshoot major export standard problems making great losses at global trade, provides a need to study their biology, bionomics and management, in this paper we focus on the important mite pests of different temperate fruit crops and their management practices.

Phytophagous mites
Although an extensive work on mites has took place since decades yet many mites remain undescribed, or their role in the ecosystem is still unknown. Mites pose as agriculture pests when they feed on plants or transmit diseases to crops. Mites attack a wide array of crops and many other organisms like honey bees, which are critical to the pollination of many 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. Not all the mites that were reported are pests, there are some mite species that are beneficial as they act as effective natural enemies of

some phytophagous mites. Some mite's species Oribatida or Cryptostigmata are important in breaking down organic material thus helps in nutrient cycling in the soil. In this paper, we focus chiefly on mites that are pests of fruit crops. There are about 12 different species of mites in India which were considered as major pests. [4, 5] The major phytophagous mites belong to families of spider mite (Tetranychidae), false spider mite (Tenuipalpidae) and gall mite (Eriophyidae) and Tarsonemidae.

Tetranychidae

Family Tetranychidae (Actinedida or Prostigmata) also known as "Spider mites", comprise the most important phytophagous mite pests of agriculture around the world, attacking food crops, trees, and ornamentals [14, 19, 2, 24]. An epidemic of spider mites can cause significant yield losses and may even lead to death of the crop plant. About 1250 species of mites are reported to feed on 3877 plants of different species, however only 100 species are considered to be economically important.[6] Total number of species is still unclear and some species may probably include cryptic species, as the taxonomy of this group is not fully resolved. Some relative few species like *Tetranychus urticae, T. cinnabarinus, T. pacicus, T. kanzawai, Panonychus ulmi, P. citri, Oligonychus punicae, O. coffeae, and Eutetranychus orientalis*) are considered major pests of important crops. Two-spotted spider mite (Tetranychus urticae), which has a worldwide distribution is the most notorious.

Life cycle

Spider mites usually prefer to feed on the lower leaf surface, but when populations are high it will readily infest the upper leaf surface. Temperature play an important role in life cycle of Spider mites complete at a temperature of 30°C these mites finish their life cycle in 8 to 12 days and in about 17 days at 20 degrees. In warmer climates these organisms overwinter on different kinds of weed hosts, but females may also overwinter in diapause stage in plant debris. Females lay 5 to 6 eggs per day, singularly with a total of 60 to 100 eggs per female. At a requisite of suitable temperatures eggs hatch in 3 to 6 days, while larva and nymphs complete development in 4 to 9 days, females have a pre-Oviposition period of 1 to 2 days. Adults live about 30 days.

Damage to crop

Spider mites generally found on the lower surface of the foliage and pierce the plant cells and suck the cell contents however higher population might end up covering the entire leaf surface. This results in a speckled appearance of infested leaves with small clumps of necrotic tissues. Desiccation, leaf deformity, Wilting and abscission occur with prolonged, high density infestations. Disruption of photosynthesis results in stunted plants and yield loss.

Table 1: Phytophagous mites on fruit crops of family Tetranychidae.

Family	Crop and Scientific Name	(Common name)	(Scientific name)
Tetranychidae	Apple	European red mite	*Panonychus ulmi* (Koch.)
		Two spotted spider mite	*Tetranychus urticae* (Koch)
		Citrus red mite	*Panonychus citri* (Mcgregor)
	Pear	Brown clover mite	*Bryobia praetiosa* Koch
	Peach, Pear	Lowveld citrus mite	*Eutetranychus anneckei* (Meyer)
		Oriental citrus mite	*Eutetranychus orientalis* (Klein)
		Red tea mite	*Oligonychus coffeae* (Nietner)
		European red mite,	*Panonychus ulmi* (Koch.)
		Two spotted spider mite	*Tetranychus urticae* (Koch)
		Citrus red mite	*Panonychus citri* (Mcgregor)
			Eutetranychus africanus (Tucker)
	Mango	Mango red spider mite	*Oligonychus mangiferus* (Rahman and Sapra)
	Citrus	Lowveld citrus mite	*Eutetranychus anneckei* Meyer
		Citrus red mite	*Panonychus citri* (Mcgregor)

Fig 1a

Fig 1b

Fig 1c

Fig 1d

Fig 1e

Fig: Damage symptoms of spider mites on Fig: 1a- apple fruit, 1-c peach fruit, 1d- peach leaves, 1e- citrus leaf, 1b- red spider mite eggs on apple stem.

Eriophyoidea

Eriophyoidea mites also called as “gall mites, blister mites, and rust mites” are considered to be second most important agricultural mite pests after the Tetranychidae. These mites have a unique relationship with host plants creating visible galls and other morphological abnormalities. Eriophyid mites have an elongated, worm-like body with two pair of legs unlike spider like body form and four pairs of legs in other mite species. Because of the mite's small size, the galls or other plant abnormalities such as rusting, leaf folding, or blistering are the most observable clues that eriophyid mites are present.

Life history

With a fairly simple life cycle eriophyid mites within a spring-summer season, develop through four growth stages: egg, first nymph, second nymph, and adult, which is also the overwintering stage, however certain eriophyid mites have a more complex life cycle with alternation of female-only generation with a male-female generation. Eriophyid that feed on deciduous plants, are supposed to have these adaptation based on the seasonal changes of the host material. Mites of overwintering, female-only generation are called deutogynes, and females associated with female-male generations are called protogynes. Shape and size, of these protogynes and deutogynes is quite variable even of the same species and are consequently difficult to identify. Eriophyid mites use hitch hiking of insects or birds and air currents to travel between hosts.

Damage symptom

Eriophyid mites have a special association with its host plant, and are usually found on the plant's fleshy tissues. Galls occur when the mites inject their saliva and serve as special sites of those mites. These galls can be of different types, and all occur on the soft parts of the host plant. Bladder, bead, finger, and pouch galls are some of these types, are often covered with hairs, or erinea, which are mite-induced plant hair growths. Plants hosting eriophyid induced erinea have characteristic hairy or fuzzy pads on their leaf surfaces or other plant parts, and the erinea can often be colorful. Eriophyid mites can also induce twig elongation, excessive bud production, as a result of their growth regulating salivary constituents. Eriophyids also cause bud swelling referred to as "big bud. They further can cause leaf edge rolling, orcan induce blisters on leaf surface and alter a plant's normal appearance [7].

Table 2: Phytophagous mites on fruit crops of family Eriophyidae.

Family	Crop and scientific name	(Common name)	(Scientific name)
Eriophyidae	Almond	Peach silver mite	*Aculus cornutus* (Banks)
	Mango	Mango bud mite	*Aceria mangiferae* Sayed
	Ber	Jujube (Ber) gall mite	*Eriophyes cernuus* Massee
	Litchi	Litchi erineum mite	*Aceria litchii* (Kiefer)

Fig 2a

Fig 2b

Fig 2c

Fig 2d

Fig; Damage symptoms of eriophyid or gall mites on Fig: 2a- litchi leaves, 2b- walnut leaves, 2c- cherry leaves, 2d- colony of eriophyid mites on walnut plant

Tenuipalpidae

Tenuipalpidae mites are also known as "false spider mites" as they closely resemble spider mites (family *Tetranychidae*) or as "flat mites" because of their flattened body in comparison to other mites. They are most common in tropical or subtropical climate and all Tenuipalpus feed on plants. [18, 19, 20, 21] Approximately 30 genera with 900 described species were reported by Gerson [21] but many may remain undiscovered on tropical and subtropical plants. Similarly Childers [22] reported that 3 species (*Brevipalpus californicus, B. obovatus, and B. phoenicis*) attack a total of 928 plant species in 513 genera in 139 families. *Brevipalpus* and *Tenuipalpus* are the two genera that cause damage to most of the plant species.

Life cycle

Tenuipalpidae mites usually have same body shape as spider mites but are usually smaller and are brick-red to yellow in colour. False spider mites do have same developmental stages as spider mites like egg, larva, proton mph, deutonymph and adult. They are found along the veins on the underside of leaves. These mites are flattened and egg shaped with dorsal surface showing a net-like pattern. The eggs are laid in clusters of hundreds along the mid vein or in leaf fold and re red in colour with elliptical shape.

Damage symptoms

False spider mites (*Tenuipalpidae*) cause damage by producing a scabby discoloration on under surface of leaf blade, collapsible patches can be found on place of feeding by mites, the damage may often leads to premature ageing, misshapen plants, however these mites do not produce webs. The false spider mite (*Brevipalpus phoenicis)* also feeds on many fruit crops like citrus, papaya and pomegranate and also known to transmit plant viruses [8].

Table 3: Phytophagous mites on fruit crops of family Eriophyidae.

Family	Crop and scientific name	(Common name)	(Scientific name)
Tenuipalpidae	Apple	Flat scarlet mite	(*Cenopalpus pulcher* (Canestini & Fanzago)
	Pear		*Tenuipalpus ludhianaenis* (Sadana and Chhabra)
			Tenuipalpus pruni (Maninder and Ghai)
			Tenuipalpus pyrusae (Maninder and Ghai)
	Citrus	Citrus flat mite	*Brevipalpus californicus* (Banks)
	Ber	Ber gall mite	*Larvacarus transitans* (Ewing)
	Guava	Scarlet mite/ Reddish black flat mite/Leprosies mite	*Brevipalpus phoenicis* (Geijskes)
			Tenuipalpus pyrusae Maninder and Ghai
	Pineapple	Pineapple flat mite	*Dolichotetranychus floridanus* (Banks)

Fig 3a

Fig 3b

Fig 3c

Fig: Damage symptoms of Fig: 3a- citrus flat mite on cirrus fruits, Fig 3b- flat scarlet mite on apple fruit, Fig 3c- Scarlet mite infestation on guava

Tarsonemidae

The family Tarsonemidae (Prostigmata or Actinedida) also called "white mites" or "thread footed mites" contains species with highly diverse feeding habits, with some species feeding on algae, fungi, and plants [19, 23] and some being parasitic mites. With three subfamilies, Tarsonemidae consists of 530 species included in 40 genera. Although mites of this family were primarily restricted to tropical and subtropical distribution, but few species are found in the Nearctic and Palearctic regions. The phytophagous Tarsonemidae mites found primarily in the Tarsonemidae and the Pseudotarsonemoidinae super families [24]. Most species of this family feed on fungi and various organic debri and are harmless. Important plant parasites are found in the genera *Polyphagotarsonemus (P. latus* (Banks), the broad mite, tropical mite, tea mite), *Hemi tarsonemus* (on ferns), *Phytonemus (P. pallidus* (Banks) the cyclamen mite), and *Steneotarsonemus* (e.g. *S. ananas* (Tryon) on pineapple, *S. bancrofti* (Michael) on sugarcane, *S. spinki* Smiley on rice). Damage by species of *Steneotarsonemus* is typically associated with fungal infections. In addition to the plant-parasitic tarsonemus, others are pests of bees, forest trees, and mushroom culture

Life cycle: Family Tarsonemidae, with only two active stages nymph and adults completes life cycle in very short duration usually with a generation time may be less than a week. Feeding period of the nymphs is quite short and directly molt in to adults. Reproduction is by arrhenotoky and the sex ratio is variable.

Damage symptoms: Feeding by these mites is mainly concentrated on the underside near the leaf stalk; leaves turn brown and curl up. Tips of affected plants get misshapen with contorted leaves and corky formations causing brown discoloration. Typical identification of broad mite (*Polyphagotarsonemus latus*), damage is the appearance of dark brown edges at the base of young leaves. Mild infestation, may lead to formation of network of brown stripes on leaves whereas serious infestation, this network becomes dense and leads to complete loss of green tissues, deformed corky patches frequently appear causing misshapen Fruits get misshapen and get crack opened at the site deformed corky patches. Flowers get discolored. Extensive damage can be caused by relatively low populations [9]. Often, the lower leaves of a plant remain. Most broad mites (*Polyphagotarsonemus latus*) are found on the undersides of young leaves. Symptoms remain visible even after several weeks after the mites have been removed.

Fig 4a

Fig 4b

Fig: Damage symptoms of broad mite on Fig: 4a- papaya, Fig: 4b- citrus.

Integrated management of mites

The Integrated management of mites is a concept of minimizing pesticide usage and managing pest population by utilization of ecofriendly methods like cultural methods, biological methods, resistant varieties, and acaricides which have less residual effects. Cultural methods is the first and foremost approach of integrated mite management which, includes plowing, and removal of stubbles after harvesting crops, fallowing of fields, and rotation with an alternate crop, and sometimes proper cleaning of machinery used in all these operations before using in an un-infested field. Biological methods provide an ecofriendly and, cost effective means of pest control either alone or as a component of IPM [10]. A certain group of mites called Phytoseiid mites are well accepted as bioagents for management of phytophagous mites. A total of 139 Phytoseiid mites with their taxonomic categories was listed by Gupta [11] from India. However, the families of Stigmaeidae, Erythraeidae, Tydeid, Anystidae, Cheyletidae and Hemisarcoptidae also contain species that are predacious [12, 13, 5] recommended bio-control using predacious mitesin mite pest management programme and suggested to follow IPM approach: (i) by utilizing naturally and locally occurring predacious mites, (ii) by releasing predatory mites and (iii) by utilizing pesticide resistant strains of predacious mites. Some of the most important predacious mite species are given in table 4. Mite control during 1920 is usually done using sulphur [14]. It is only in 1952 the so called dicofol was made which has been extensively used in tea gardens of India. Commercially this formulation is available as kelthane, hilfol etc. The acaricides like mores tan, cyhexatin (Plictran) and chlorodimeform (Galecron) which emerged after 60s are not being frequently used in India. Phosalone (Zolone), dinocap (Karathane), ethion (Phosmite), tetrad form (Tedion) are also not very popular acaricides or used moderately. Insectoacaricides from the group of organ phosphorus compounds are often used in India for mite control. These insectoacaricides are Dimeton (Metasystox), Disulphoton, Thiodemeton (Disyston), Quinalphos (Ekalux), Thiometon (Ekatin), Formothion (Anthio), Phosphamidon (Dimecron), Carbaryl (Sevin) and Dimethoate (Roger). Modifying environmental conditions temporarily has proven to be an effective method for insect pest control including spider mites. Generally dramatically decreased oxygen and increased carbon dioxide concentrations at elevated temperatures can lead to mortality at all developmental stages. However mild CO_2 enrichment has been shown to in fact increase mite reproduction.[15] One study determined a concentration of 0.4% O_2 and 20% CO_2 gave a LT_{99} (time to 99% mortality) of

113h at 20 °C and 15.5h at 40 °C [16]. Another study reported 100% mortality of various stages of the two spotted spider mite using 60% CO_2 and 20% O_2 at 30 °C for 16h [17]. Advantages would include decreased ability for resistance development compared to miticides and potential ease of application while drawbacks might include sensitivity of the plant to the conditions, feasibility of application, and human safety.

Table 4: List of predatory mite species and their prey mites.

S. No	Pery mite	Predatory mite	Family of predatory mite
1	*Eutetranychus orientalis,*	*Amblyseius bambusae* Ghai and Menon	Phytoseiidae
2	*Panonychus ulmi*	*Typhlodromus mori* Gupta	Phytoseiidae
3	*Panonychus ulmi*	*Typhlodromus pruni* Gupta	Phytoseiidae
4	*Tetranychus urticae,*	*Typhlodromus occidentalis* Nesbitt	Phytoseiidae
5	*Panonychus ulmi, Tetranychus urticae,*	*Zetzellia mali* Ewing	Stigmaeidae
6	*Eutetranychus orientalis, Panonychus ulmi, Tetranychus urticae*	*Amblyseius alstoniae* Gupta	Phytoseiidae

(*Source*: Singh *et.al Insect pest management of fruit crops*)

Conclusion

Phytophagous mites gaining economical importance lately in horticultural crop production mainly fruit crops as they can be devastating to crops when not controlled adequately but also reduce their quality standards in international and national trade. The Knowledge of their biology, occurrence and mode of damage aids in formulating effective control measures. A vast majority of acaricides were used to target these mites, especially in fruit and vegetables, which can pose resistance issues, development of new strains, and also pest resurgence. More recently developed compounds with new mode of action target the mite ACC, and electron transport at complex II and complex III. A judicious use of acaricides in combination with IPM is the best approach to achieving sustainable mite control.

References

1. Verma MK, Ahmad N, Singh AK, Awasthi OP. Temperate tree fruits and nuts in India chronica horticulturae. 2010; 50:43-48.
2. https://www.elitetreecare.com/library/tree-pests/mites/
3. Batra SWT. Automatic image analysis for rapid identification of Africanized honey bees. In: Africanized Honey Bees and Bee Mites (Needham GR. Page RE Jr. Delfinado-Baker M. & Bowman CE. eds.), Ellis Horwood Ltd., Chichester, 1988, 260-263.
4. Gupta SK. The mites of agricultural importance in India with remark on their economic status. In: *Modern acarology* (eds. F. Dusbabek and V. Bukva) Academia, Prague, 1991; 1:509-522.
5. Singh J, Singh RN, Rai SN. Expanding Pest Status of Phytophagous Mites and Integrated Pest Management. IPM System in Agriculture (eds: R.K. Upadhayay, K.G. Mukherjee and O.P. Dubey), New Delhi, India. 2000; 7:1-29.
6. Migeon, Alain, Dorkeld Franck. Spider mites web: A comprehensive database for the Tetranychidae, 2014. http://www.montpellier.inra.fr/CBGP/spmweb.
7. Leiden, Brill EJ. Progress in Acarology, edited by GP. Channabasavanna, CA. Viraktamath. Rekha Printers PVT. Ltd., Okhla Industrial area, New Delhi. 1989; 1:20. https://www.koppert.co.uk/challenges/spider-mites-and-other-mites/false-spider-mites/ https://www.koppert.co.uk/challenges/spider-mites-and-other-mites/broad-mite/
8. Hoy MA, Westigard PH, Hoyt SC. Release and evaluation of a laboratory selected pyrethroid resistant strain of the predaceous mite metaseilus occidentalis in southern oregon pear orchards and a washington apple orchard. Journal of economic entomology. 1983; 7:383-388.
9. Gupta SK. A taxonomic review of oriental Phytoseiidae with key to genera and by mites (eds. M.A. Hoy, G.L. Cunningham and L. Knutson) University of California, Berkely, 1987, 28-35.
10. Laing JE, Knop NE. Potential uses of predaceous mite other than pests. In: Progress in acarology, (eds. G.P. Channa Basavanna and C.A. Viraktamath) Oxford and IBH, New Delhi, 1983; 2:337-341.
11. Rasmy AH. Prospects of biological control in integrated management of mite species. Records of the Z.S.I. Miscellaneous Pub. Occasional paper No. 95. University of California Press, California, Berkeley, 1989.
12. Jeppson LR, Keifer HH, Baker EW. Mites injurious to economic plants. University of California Press, California, Berkeley, 1975.
13. Anonymous Table 4. Toxicity to fish of commonly used insecticides, miticides, and nematicides. Virginia Tech, 2016.
14. Whiting DC, Van Den Heuvel J. Oxygen, carbon dioxide, and temperature effects on mortality responses of diapausing *Tetranychus urticae* (Acari: Tetranychidae). Journal of economic entomology. 1995; 88:331-336.
15. Oyamada Koichi, Murai Tamotsu. Effect of fumigation of high concentration carbon dioxide on two spotted spider mite, *Tetranychus urticae* Koch (Acari: Tetranychidae) and strawberry runner plant. Japanese journal of applied entomology and zoology. 2013; 57:249-256.
16. Pritchard AE, Baker EW. The false spider mites (Acarina: Tenuipalpidae). University of California Publ. Ent. 1958; 14:175-274.
17. Meyer MKP, Smith. Mite pests of crops in southern Africa. Sci. Bul. Dept. Agric. Fish Repub. S. Afr. No. 1981; 397:92.
18. Baker EW, Tuttle DM. The false spider mites of Mexico (Tenuipalpidae: Acari). U. S. Department of Agriculture, Technical Bulletin. 1987, 1706.
19. Gerson U, Collyer E. Two false spider mites (Acari: Tenuipalpidae) from Cook Islands and New Zealand ferns. New Zealand journal of zoology. 1984; 11:141-144.
20. Childers CC, Rodrigues JCV, Welbourn WC. Host plants of *Brevipalpus californicus, B. obovatus* and *B. phoenicis* (Acari: Tenuipalpidae) and their potential involvement in the spread of viral diseases vectored by these mites.

Experimental and Applied Acarology. 2003; 30:29-105.
21. Lindquist E. Anatomy, phylogeny and systematics. External anatomy. *In*: Helle, W. & Sabelis M. W. (Eds.) Spider mites, their biology, natural enemies and control. World Crops Pests. 1985; 1:3-28.
22. Zhang ZQ. Mites of Greenhouses: Identification, Biology and Control. CABI, New York, 2003, 240.
23. Bolland HR, Gutierrez J, Fletchmann CHW. World Catalogue of the Spider Mite Family (Acari: Tetranychidae). Brill, Leiden, Boston, Koln, 1998, 392.
24. Indian Horticulture Database. National Horticulture Board, Ministry of Agriculture, Government of India, 85, Industrial Area, Sector-18, Gurgaon-122015, India, 2010.