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Citation : Dhooria, M.S., Bhullar, M.B. and Mallik B. 2005, *Mite pests of citrus and their management in India.* 28 pp. AINP (Agricultural Acarology), UAS, Bangalore

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Published by :
Network Co-ordinator
All India Network Project (Agricultural Acaralogy)
Department of Entomology
University of Agricultural Sciences
Bangalore - 560 065

Cover Photo : Citrus fruit damaged by *Phyllocoptruta oleivora*

No. of Copies : 500

Printed at :
Navbharath Enterprises
Seshadripuram, Bangalore - 560 020
Ph : 2336 4142, 2336 4682
E-mail : navbarat@blr.vsnl.net.in

Foreword

Citrus ranks third in area among the fruits grown in India, and India ranks sixth among the citrus growing countries of the world. Citrus orchards occupy an area of 4,54,000 hectares in the country with an annual production of 3.86 million tonnes of fruits. However, average productivity of citrus at the national level is quite low i.e., 8.8 tonnes/ha as compared to 25-30 tonnes/ha in developed countries. Menace by different insects and mites have been considered as one of the most important factors for this low productivity.

Twenty-five species of phytophagous mites have been reported feeding on citrus crop, some of these are responsible for significant loss in yield. Mites suck the sap of leaves, which results in decreased photosynthesis. Species like Brevipalpus phoenicis feed mainly on fruits and cause corkyness on the fruit rind causing significant reduction in their market value. Such fruits are not considered suitable for export. Another mite, citrus rust mite, Phyllocoptruta oleivora, which is very small (150-160 μm) feeds especially on the citrus fruits, multiplies rapidly, as a result of its damage the fruits look reddish brown to purplish black. Affected fruits also develop comparatively thicker skin with rusty spots and have low market acceptance.

Considering the significance of different mite problems as regards their influence on quality and quantity of fruits produced, the present booklet "Mite-pests of citrus and their management in India", in which all the available information from India such as field identification, biology, ecological conditions favouring their multiplication, nature of damage, control measures and different strategies for managing the mite pests are included will enable fruit entomologists to intensify studies on the mite problems so that India will be able to play a major role in the global market..

I congratulate the authors for this timely publication.

Dr. G. Kalloo
Deputy Director General (Horticultural & Crop Science)
Indian Council of Agricultural Research, New Delhi

MESSAGE

I am very happy to note that scientists of the AINP on Agricultural Acarology have brought out this very useful publication "Mite pests of citrus and their management in India", highlighting the field identification of mites and their damage, suitable ecological conditions for their development, chemical control along with strategies to manage them. This booklet is highly informative, includes pictures of mites and their damage facilitating easy identification in the field. I appreciate the sincere efforts of the authors in bringing out this excellent publication, which can serve as a guide to horticulturists for improving the quality and yield of citrus in India.

Dr. O.P. Dubey
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MITE PESTS OF CITRUS AND THEIR MANAGEMENT IN INDIA

Citrus is a general term, which refers to a large number of species of fruit trees in the family Rutaceae. It includes grapefruit, lime, lemon, malta, mosambi, orange and pomelo. Most of these fruits are of Indian origin, rest have been introduced from South-East Asia, Southern China and West Indies. Citrus fruits are rich in vitamin C and mineral salts, and are consumed as dessert, squashes, marmalades, pickles and jellies. They are also used in the preparation of a large number of concentrated products like citric acid, pectin etc.

Citrus ranks third (next to mango and banana) in acreage among the fruits grown in India, and India ranks sixth among the citrus growing countries of the world. Brazil, USA, Mexico, Spain and China are the leading producers of citrus. In India citrus orchards occupy an area of 4,54,000 hectares with an annual production of 3.86 million tonnes of fruits. Average productivity of 8.8 tonnes/ha at the national level is quite low, compared to 25-30 tonnes/ha in developed countries (Shivankar and Singh, 2005). In spite of adoption of improved management practices by the growers there are reports of decline in the yield of citrus trees after 6-7 years of profitable production. Several factors have been contributing for this decline, however menace by different insects and mites have been considered as one of the most important factors (Bindra, 1970). More than 30% of citrus production in the country is lost every year as a result of damage by insect and mite pests (Pruthi and Mani, 1945; Butani, 1979a and

Table 1. Phytophagous and predaceous mite species associated with citrus in India

A. Phytophagous Mites	B. Predaceous Mites
I. Family ñ Tetranychidae	**I. Family ñ Cheyletidae**
1. *Eotetranychus kankitus*	1. *Cheletomorpha lepidopterorum*
2. *E. mandensis*	**II. Family ñ Erythraeidae**
3. *E. palmalae*	2. *Leptus giganticus*
4. *E. sexmaculatus*	**III. Family ñ Stigmaeidae**
5. *Eutetranychus africanus*	3. *Agistemus fleschneri*
6. *E. orientalis*	**IV. Family ñ Tydeidae**
7. *E. citri*	4. *Pronematus fleschneri*
8. *Oligonychus coffeae*	**V. Family- Ascidae**
9. *Panonychus citri*	5. *Lasioseius quadrisetosus*
10. *Petrobia latens*	**VI. Family- Phytoseidae**
11. *Schizotetranychus baltazarae*	6. *Amblyseius aerialis*
12. *S. hindustanicus*	7. *A. assamensis*
13. *Tetranychus urticae (= cinnabarinus)*	8. *A. cocciniae*
14. *T. fijiensis*	9. *A. cucumeris*
15. *T. neocaledonicus*	10. *A. delhiensis*
Family ñ Tenuipalpidae	11. *A. deleoni*
16. *Brevipalpus californicus*	12. *A. hibisci*
17. *B. deleoni*	13. *A. kalimpongensis*
18. *B. lewisi*	14. *A. largoensis*
19. *B. phoenicis*	15. *A. mcmurtryi*
Family ñ Eriophyidae	16. *A. paraerialis*
20. *Aceria sheldoni*	17. *A. salebrosus*
21. *Diptilomiopus assamica*	18. *Typhlodromus fleschneri*
22. *Floracarus fleschneri*	19. *T. homali*
23. *Paratetra murrae*	20. *T. rhenanus*
24. *Phyllocoptruta oleivora*	21. *T. rickeri*
25. *Phytoptus ficivorus*	22. *T. bambusicolus*
Family ñ Acaridae	
26. *Tyrophagus longior*	

1979b). Forty-two species of mites, of which 25 species are phytophagous (Table 1), have been reported on citrus from India (Prasad, 1974; Dhooria and Gupta, 1998). Losses due to injury by mites are quite substantial especially during years when climatic conditions are more favourable for their development. LeClerg (1965) recorded 2.5% loss in production of citrus fruits due to damage by spider mites alone, in United States.

Seven species of phytophagous mites, namely : spider mites- *Eutetranychus orientalis* (Klein) and *Panonychus citri* (McGregor) [Family Tetranychidae]; false spider mites-*Brevipalpus phoenicis* (Geijskes) and *B. californicus* (Banks) [Family Tenuipalpidae]; tarsonemid mites- *Polyphagotarsonemus latus* (Banks) [Family Tarsonemidae]; and eriophyid mites- *Eriophyes sheldoni* (Ewing) and *Phyllocoptruta oleivora* (Ashmead) [Family Eriophyidae], have been reported as serious pests of citrus from different parts of India (Cherian, 1931; Nagarajan, 1967; Dhooria *et al.*, 1987). A brief account of their identity, biology, ecology, damage caused, control and strategies to manage them are detailed herein.

I. Citrus brown mite, *Eutetranychus orientalis* (Klein)

Female of *Eutetranychus orientalis*

This mite species commonly known as oriental red mite, citrus mite and citrus brown mite, was described by Klein (1936) under the name *Anychus orientalis*. But Rahman and Sapra (1940) also described the same species under the name *Anychus ricini*. Both these names were considered synonyms of *Eutetranychus banksi* (McGregor) by Pritchard and Baker (1955). However, Baker and Pritchard (1960) considered *orientalis* as a valid species, different from *banksi,* and *Anychus ricini* Rahman and Sapra as its synonym. Prasad (1974) placed *E. banksi* reported by ChannaBasavanna and Puttarudriah (1957) under *Eutetranyhus orientalis* and this was supported by Gupta (1985).

Host-range and distribution : *Eutetranychus orientalis* has a very broad host range, more than 85 plant species distributed in 28 different plant families have been reported as hosts of this mite from India (Rahman and Sapra, 1940; Banu and ChannaBasavanna, 1972; Sadana, 1972; Sadana and Kanta, 1972; Lal and Mukherji, 1979; Dhooria, 1982; Rai *et al.,*1964 and Sethi, 1967), however, maximum number of hosts are found in Rutaceae and Rosaceae. Citrus species, *Cassia fistula*, *Ricinus communis*, *Cannabis* sp., *Nerium oleander, Azadirachta indica*, *Melia azadirach*, *Dalbergia sisso*, Indian coral tree, papaya, almond, peach, pear and curry-leaf are the most important host plants of this mite. *Eutetranychus orientalis* has been reported from several countries such as Afghanistan, Cyprus, Taiwan, Egypt, India, Iran, Israel, Jordan, Kenya, Lebanon, Mozambique, Pakistan, Sudan, Turkey and Venezuela as a pest of citrus and many other cultivated plants. It has been reported as a pest of citrus especially at lower altitudes (Hill, 1975).

Biology : During development the citrus oriental mite passes through egg, larva, protonymph, deutonymph and adult stages. Observations on the development of this mite have been reported by Kanta (1971), Banu and ChannaBasavanna (1972), Lal (1977), Dhooria(1984) and Das and Gupta (1991). Larval, protonymphal and deutonymphal periods have been reported on lemon at 30^{o}C to be 1.41, 1.50 and 1.50 days, respectively with mean pre-oviposition, oviposition and post-oviposition periods of 1.40, 5.00 and 1.20 days, respectively (Kanta, 1971). Banu and ChannaBasavanna (1972) reported 12-13 days as the total developmental period (egg to adult), and 51.3 eggs as the average fecundity per female. Dhooria (1985) studied the development of *E. orientalis* on castor, French bean, lime and mandarin leaves at 30^{o}C. Comparatively faster development of mite was reported on leaves of castor, French bean and lime than on mandarin. Mean larval, protonymphal and deutonymphal durations were shorter, while fecundity and longevity were high on fresh leaves.

Damage symptoms : Mites suck the sap of leaves predominantly from the upper surface of leaves, the affected leaves turn chlorotic and finally drop off resulting

in poor plant growth. Infestation of mite normally starts along the midrib of leaves and later spreads along lateral veins, as a result the region on either side of the midrib and veins turn pale-yellow. In case of severe mite infestation, the upper leaf surface turns pale completely. The webbing produced by the mite trap dust particles, hence the infested leaves are covered with fine dust particles. However, the lower surface remains free of mites and their feeding injury, and appears normal green. In some cases, mite infested fruits also appear chlorotic (Banu and ChannaBasavanna, 1972).

Colony of oriental mite, *Eutetranychus orientalis*

Seasonal incidence : On citrus peak population has been reported during March-June, and September-October. Positive correlations between temperature and mite population are reported on different citrus species, while, rainfall and relative humidity showed negative correlation with mite population (Dhooria and Butani,1983; Gangwar and Lal, 1988 ; Singla and Sadana, 1998).

Varietal suscepitibility: Eitrong citrus (*Citrus medica*), lime variety ìkagzi limeî, *C. sinensis*, *C. aurantifolia* and sweet orange are relatively resistant to mite attack (Sadana and Kanta, 1971 ; Dhooria, 1982 ; Makar *et al* , 1983 ; Singh *et al*., 1983a ; Bhumannavar *et al*., 1988 and Kapur-Ghai and Kaur,2003a and 2003b). Sour lemon variety ëgalgalí, sweet lime (*C. limmetioides*), ëKharna khattaí, grape fruit and *Citrus acida* were most susceptible (Sadana and Kanta, 1972; Dhooria, 1982; Naqvi and Sharma, 1993). Among different root stocks, *Citrus aurantiifolia* has been found resistant followed by *Citrus reshini* and *C. amblycarpa* (Makar *et al.*, 1983).

Chemical control : Soil application of aldicarb @ 0.5 g a.i./nursery plant, has been reported very effective in controlling the mites upto 70 days after application. Disulfoton @ 1.5 and 2.0 g a.i./plant was also effective

(Dhooria, 1983). Dicofol, phosphomidan, monocrotophos, ethion and dimethoate have been reported quite effective as foliar sprays on plants other than citrus (Rai *et al*., 1964; Dhooria and Sandhu, 1973 and 1975; Lal and Pillai, 1979; Dhooria and Butani, 1981; Dhooria, 1980; Verma *et al.*, 1982). Dhooria (1980) studied the relative toxicity of different pesticides against different stages of citrus mite. In general, chlorinated pesticides i.e. chlorfenethol, chlorfenson, dicofol and tetradifon were more toxic against eggs, larvae and nymphs. Fenpropathrin, fenthion, monocrotophos, oxydemeton methyl and sulphur were found more toxic to adult mites than dicofol. Singh *et al.* (1983b) found permethrin (Ambush 5EC @ 1ml/litre) to be most effective against mites infesting mandarin in Karnataka.

Natural enemies : Both predatory mites and insects have been found feeding on different stages of the citrus mite. Coccinellid beetle, *Scymnus gracilis*, and thrips, *Scolothrips indicus* are the important insect predators. Predatory mites, *Amblyseius cucumeris*, *A. hibisci*, *Pronematus* sp. and *Agistemus* sp. are frequently associated with this mite (Sadana and Kanta, 1972; Dhooria, 1981).

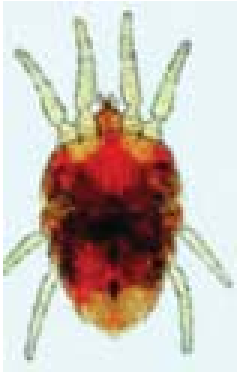
Dhooria (1981) found both nymphs and adults of the phytoseiid mite, *Amblyseius alstoniae* Gupta, actively feeding on all stages of citrus mite. First and second instar nymphs and adults of the predatory thrips, *Scolothrips indicus* were noticed feeding actively on eggs, nymphs and adults of the mite. First instar larvae of the predatory beetle, *Stethorus pauperculus* feed on eggs and larvae of the mite, later stages feed on deutonymphs and adult females.

II. Red and black flat mite, *Brevipalpus phoenicis* (Geijskes)

This is a red coloured mite with dark patterns that develop on the body as it becomes older. The eggs are elliptical, reddish-orange in colour and are laid singly in sheltered spaces.

Host-range and distribution : This mite has a very broad host-range (Nageshachandra and ChannaBasavanna, 1976; Sandhu *et al*., 1979) and has been reported as a pest of apple, guava, grapes, pear, peach, papaya, tea and coffee, besides many ornamental plants. This mite has been reported on 49 plant species

in Punjab (Gupta, 1985; Kumari and Sadana, 1990). This species is distributed throughout the world (Jeppson *et al.*, 1975). From India, this has been reported from all the citrus growing areas.



Tenuipalpid mite
Brevipalpus phoenicis

Biology: From India, studies on biology of this mite on citrus have not been reported. However, Banerjee (1965) studied its biology on tea under laboratory conditions, and reported that its life cycle is completed in 15-22 days at 23±3°C and 85% relative humidity. Lal (1979) reported that duration of life cycle was more affected by temperature than food. Kumari (1989) reported a combination of 25°C and 70% relative humidity as most suitable for development of this mite on guava.

Damage symptoms: Mites feed on both leaves and fruits but infests more severely younger fruits. On leaves, occasionally diffused chlorotic patches referred as ëphoenicis blotchí are found in case of heavy infestation. Mite damage is particularly severe on plants, which are stressed. Variety of symptoms in association with mite attack has been reported on fruits and leaves of different species of citrus. Defoliation and even death of nursery plants from Venezuela as a result of combined attack of *B. phoenicis* and fungus, *Elsinoe fawcetti,* has been reported (Jeppson *et al.*, 1975).

Rind-disorder of kinnow caused by *Brevipalpus phoenicis*

Dhooria *et al.* (1997) reported *B. phoenicis*, associated with rind-disorder of different citrus fruits, from November to February in Punjab. Size of rind-disordered area on fruits ranged from 0.5-1.5 cm across; from 15 to 25 adult mites along with several younger stages were found on each infested fruit. Mites damaged epidermal region mainly and infested fruits looked brown to blackish with irregular corky skin. However, rind-disordered fruits did

not adversely affect fruit yield and sweetness of juice. But such fruits fetched 15-20 per cent less price from market because of customersí preference for blemish-free fruits. However, Chander and Srivastava (1994) reported that frost and fluctuating temperatures are responsible for rind-disorder symptoms, and no insect or pathogen is associated with such symptoms. Chaudhri and Mali (1978) from Ahmednagar, reported association of *B. phoenicis* with citrus leprosis.

Varietal susceptibility: Kinnow fruits were more severely damaged and sometimes more than 50 per cent marketable fruits exhibited mite damage symptoms. Grapefruits, pomelo and orange fruits exhibited 10-15 per cent mite damaged fruits. In case of Blood Red, Jaffa, Musambi and Valencia Late, negligible rind-disorder symptoms were found in different localities (Dhooria *et al.*, 1997). Sadana and Joshi (1979) on the basis of mite injury on leaves reported sweet lime as most susceptible and Satsumas, Marsh grapefruit and Dancy tangerines as least susceptible.

Chemical control: No specific acaricidal control trials against this mite on citrus have been reported from India. The mite can be effectively controlled with the ususal miticidal compounds used against other mites.

Natural enemies: The phytoseiid mite, *Typhlodromus homali* Gupta has been reported commonly feeding on *B. phoenicis* (Kumari and Sadana, 1990).

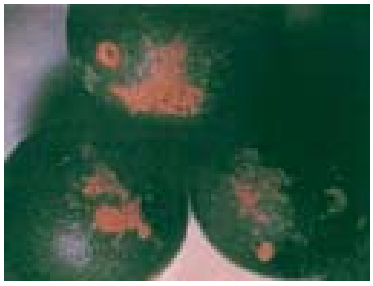
III. Silver mite, *Brevipalpus californicus* (Banks)

This is a very small flat mite, not visible to the unaided eye. The body of adult female is oval, red, with a dark red pattern along the central line of the body. It is very similar to *B. phoenicis* except for pattern of reticulations on the dorsal surface of body. Males are more pointed and do not have the dark red pattern on the body.

Host-range and distribution : The mite has very wide host-range and is extensively distributed in different parts of the world. From India, the mite has been frequently reported on citrus from West Bengal, Assam, Karnataka and Punjab and on more than 70 other host plants (Sadana and Joshi, 1976; Gupta, 1985).

Biology : The eggs of *B. californicus* are elliptical and bright red. They are covered with a sticky substance and are tightly glued to the leaf surface. Adult mites are red coloured with black patterns and move slowly. Incubation period is about 9 days at 18-24°C and 55% RH. Larvae are usually dull-red, following feeding for sometime a characteristic black pattern develops on their body. Larval plus nymphal development is completed in 21-25 days. Female lays one egg per day in her life span of about 25 days. Sadana and Joshi (1986) studied development of *B. californicus* during different months, under laboratory conditions and observed faster development of mite in May while it was minimum during March. Fecundity per female ranged from 8.2 to 12.0 days, and a female laid on an average of 0.96 to 1.83 eggs per day. The above authors concluded that the mite developed rapidly during summer months (May-July).

Damage symptoms : Mite feeding has been reported to produce variety of damage symptoms on citrus. From Argentina and Florida (USA) *B. californicus* has been reported to cause ëleprosisí type symptoms on citrus leaves. Mite has been reported to inject toxic substances during feeding along with its saliva and result in a condition known as ënail-head rustí on leaves and fruits. On fruits, mite feeding results in silvering of the fruit, while on twigs and branches mite feeding causes scaly bark commonly known as ëFlorida scaly barkí. Similar symptoms have also been referred in literature as ëlepra explosivaí or ëleprosisí. Feeding by *B. phoenicis* has also been reported to cause rind spotting in case of grapefruits (Pena *et al*., 2002).



Citrus fruits damaged by *Brevipalpus californicus*

Varietal susceptibility : Sadana and Joshi (1979) tested 25 different varieties of citrus for their comparative susceptibility to *B. californicus* and found sweet lime to be highly susceptible. Grapefruit and Dancy tangerines were found least susceptible.

Chemical control : Malathion (0.05%) has been reported as an effective compound against *B. californicus* on sweet lime (Gupta *et al*., 1971).

IV. Citrus red mite, *Panonychus citri* (McGregor)

Citrus red mite - *Panonychus citri*

These mites are reddish coloured with reddish dorsal setae on strong tubercles, the striae on genital plate are transverse and that on the area anterior to it are longitudinal. The eggs of the mite are also red, nearly spherical, somewhat flattened, and stalked with guy fibrils radiating from the tip of the stipe to the substrate.

Host-range and distribution : Other than citrus, rose, almond, pear, castor and beans, several broad-leaved evergreen ornamentals are also important hosts of this mite (Jeppson *et al*., 1975). *P. citri* has been reported as a most serious pest of citrus in California (USA), South Africa, Japan, China, South America, USSR and India. From India this mite has been reported feeding on citrus from Assam, Meghalaya, Jammu & Kashmir, Punjab, West Bengal and Andaman Islands.

Biology : Development from egg to adult is completed in 14.75 days at 23.6°C and 65% RH. Female longevity varies from 7-11 days and that of males from 6-9 days. Each female lays 50 pearly white, sub-spherical eggs. Most favourable temperature and humidity for its development are 30°C and 49% RH, respectively. Mites remain active during August- March but are rarely found during hot summer.

Damage symptoms : Mite injury on leaves includes stippling, light coloured spots, and a greyish or silvery appearance, very similar to injury produced by European red mite on apple trees. Injury is most severe when high mite infestation is associated with high transpiration rate owing to drought. In such circumstances, there may be heavy leaf and fruit drop.

Seasonal incidence : Mite population on orange trees increases most rapidly on the new growth during the spring and fall, unless the weather conditions during this period is unfavourable for mite development. Mites also develop on fruits; green fruits are more preferred than yellow fruits. But during winter monthís

fruits of navel orange harbour more mites than the leaves. Extremely hot days (40-50°C) or several days of hot and dry weather accompanied by wind usually leads to high mite mortality. Prolonged periods of high humidity are also unfavourable for the development of the mite. Susceptibility to extremes of temperature and humidity limit the distribution of this species and alter the seasonal trends.

Chemical control: The mite can be controlled using the compounds reported effective against *E. orientalis.*

V. Citrus bud mite, *Eriophyes sheldoni* Ewing

Eriophyid mite, *Eriophyes sheldoni*

The citrus bud mite is worm like, 170-180 µm long, pale yellow, microscopically small and can be seen with difficulty with a hand lens. The bud mite attacks all species of citrus, but lemon is most damaged. It occurs in almost all lemon growing areas of the world where humidity is high enough for it to develop.

Host-range and distribution:

Biology : Each female lays about 50 pearly white, sub-spherical eggs in her lifetime. Eggs hatch in 3-4 days, hatching is most successful at 25°C and 98% RH. However, egg hatching is significantly reduced when the relative humidity is low (35-40%). One generation is completed in 12-33 days.

Lemon buds malformed by *Eriophyes sheldoni*

Damage symptoms : Attack by this mite is common on lemon, particularly in the coastal belts. Under suitable conditions, it attacks all varieties of citrus but lemon is the most preferred host because of its larger buds, which offer good protection to the mite. The mites are found under bud bracts, on petiole bases next to buds, beneath bud scales, developing flowers, and under fruit buttons. All stages of buds including

dormant buds on the old wood are found infested by the mite. Mites move to new growth, and confine themselves under fruit buttons as soon as the buttons touch the growing fruit.

In case of lemon, feeding by the mites within leaf-axil buds results in the principal injury, bud scales are blackened and often the entire bud is killed. Adventitious buds appear due to mite injury, continuous injury results in extensive multiple budding on infested twigs, cessation of twig growth and blossom development. Mite-infested buds are shortened or thickened, and flattened. Sometimes on lemon trees, rosette growth is seen due to bud proliferation. Leaves from damaged buds assume peculiar shapes, blossoms are malformed with abnormal or aborted floral parts. Fruits formed from infested flowers may drop prematurely or assume odd shapes. Depending on the extent of blossom injury fruits sometimes assume round shape rather than being ellipsoidal. Symptoms on orange trees are not as pronounced as on lemon. Feeding by *E. sheldoni* flattens the oranges vertically, and ridges and seams appear on the rind.

Chemical control : One spray of lime sulphur 2% effectively controls the mites. Even mineral oils (light) and triazophos have been reported to be effective against the bud mite. These pesticides do not have any adverse affect on predaceous mites (Meyer, 1981).

VI. Broad mite, *Polyphagotarsonemus* (=*Hemitarsonemus) latus* (Banks)

This mite is commonly known as yellow tea mite, broad mite or tropical mite. The eggs of the mite are oval and elongate. The upper surface of the egg is studded with whitish tubercles in clumps. The larvae, except for size, resemble the adult. The nymphs remain enclosed within skins of the quiescent larvae until the adult is formed. The adult female is large, oval and broad, rich amber or dark green. The colour of the mite depends on the food and the host. Young females differ from full-grown females being subcircular, less deeply pigmented and in having a pair of posterior lateral setae

Tarsonemid mite, *Polyphagotarsonemus latus*

situated on the last body segment. The adult male is short, broad, tapering at the posterior end, with large fourth pair of legs, and is colourless when young, but rich amber when fully developed. At the apex of the ventral side of the male is a sucker-like organ, which is used to hold and carry the female quiescent nymph (Meyer, 1981).

Host-range and distribution : Leaf-curl mite has very broad host-range (Singh, 1996 and Dhooria, 1996). More than 31 plant species belonging to 11 different families have been reported as hosts of this mite. Although this mite damages many crops, its attack on major crops such as citrus, tea, tobacco, potato, chillies, gerbera, dahlia and jute is of great concern. This mite is distributed throughout the tropics, and also in the greenhouses on a wide variety of plants in temperate regions and on a wide variety of agricultural crops.

Biology : Females and males have an average longevity of 13.44 days and 12.0 days respectively. The intrinsic rate of increase (r_m) is 0.359, with a mean generation time of 10.34 days and net reproductive rate (Ro) of 41.0. One generation is completed in 4 to 5 days during summer and in 7 to 10 days during winter. Female deposits an average of 3.6 eggs/day, but activity and reproduction are seen throughout the year. Eggs are laid in depressions on the leaf or fruit surfaces, firmly attached at the base. The males may be found commonly transferring the colony from mature to young leaves by carrying female nymphs aimlessly. Mites are numerous in damp, shady areas. Singh (1996) studied biology of leaf-curl mite, *P. latus*, on chilli under laboratory conditions and found that development of mite was completed in a shorter duration at 27°C (4.57 days) than at 22.5°C (5.71 days). A female laid an average of 7.16 eggs at 22.5°C and 5.61 eggs at 27.5°C.

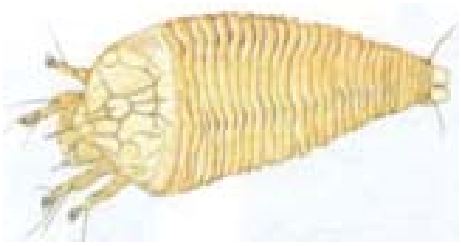
Damage symptoms : On citrus, mites feed on the lower surface of leaves, causing the leaves to become rigid and curled. Feeding injury is confined to young foliage, nursery plants are affected more. On ageing, the damaged leaves

split or crack producing a ragged appearance of various shapes. The ventral surfaces of infested leaves become bronzed. Mites also attack citrus fruits leading to silvery-white symptoms, which later turn corky (Dhooria *et al.*, 1987; Pena *et al.*, 2002). Attack is concentrated on the young leaves. Sometimes mites cause damage to stems, flowers, fruit-lets. Comparatively hot humid weather is congenial for feeding and breeding of the mite. Intensity of damage will be high during such periods. The principal damage symptoms consist of deformation of the leaves and suberization of the floral buds, growing tips and fruit. The symptom of feeding by the broad mite on citrus is the formation of thin silver-grey skin that can be easily rubbed off. Salivary toxins injected during feeding affects normal tissue development in the host plant. On limes, large number of mites is found on shaded portion of the fruit compared to the stylar, peduncle and portion exposed to light. This is due to the tendency of the mites to avoid portions of the fruit exposed to sunlight or low relative humidity. Due to mite damage various physiological processes are affected resulting in changes in growth, flowering and yield. Total leaf area and leaf water content is reduced as a result of mite infestation. Under greenhouse conditions, limes begin to show damage 4-6 days after infestation and severe damage to the fruit epidermis appears 12 days after infestation or when lime fruits have attained two-third size. In coastal areas, when 5% of the fruits are infested, plant protection measures should be initiated. In Florida, economic injury level per lime tree lies between 42 and 45 broad mite days for the spring and summer seasons respectively (Pena *et al.,* 2002).

Chemical control : Propargite, dicofol, carbophenothion and avermectins have been found effective against broad mites. Mite infested plants can also be dusted with sulphur 2-3 times at 5-days intervals. Fumigation with calcium cyanide or naphthalene has also been reported to be effective (Pena *et al.*, 2002).

Natural enemies: Singh (1996) reported association of very low population of predaceous mite, *Amblyseius* spp., *Agistemus* spp., and *Pronematus* spp. with leaf-curl mite on chilli.

VII. Citrus rust mite, *Phyllocoptruta oleivora* (Ashmead)



Eriophyid mite, *Phyllocoptruta oleivora*

Citrus rust mite is very small (150-165µm), fusiform, dorsally flattened and yellow. The eggs are smooth, spherical, semi-transluscent and are laid in groups in indentations on fruits and on ventral surfaces of leaves.

Host-range and distribution : This species has been reported as a serious pest of citrus in different parts of the world (Rao *et al.*, 1957). The mite reproduces rapidly and its feeding on fruits adversely affects the external appearance of the fruits.

Biology : At 32°C, mean incubation period is 3 days and nymphal development is completed in 2-11 days. The life cycle is completed in 7 to 10 days in summer and 14 days in winter. A female lays 20 to 30 eggs during a life span of 20 days (Meyer, 1981). Kalaisekar *et al* (2003a) also studied biology of citrus rust mite on fruits of sweet orange.

Nature of damage : Fruits are attacked when they are of size of peas, damaged fruits become silvery, reddish brown or purplish black, sometimes whole surface of the fruit is damaged. Affected fruits bear a comparatively thicker skin and have rust spots, which render them unacceptable in the market (Rao *et al.*, 1957; Meyer, 1981; Kalaisekar *et al.*, 2000). On grapefruit and lemons feeding by this mite results in a silvered or shark-skin appearance.

Sweet lime fruits damaged by *Phyllocoptruta oleivora*

Damaged fruits remain small in size and deteriorate rapidly. High rust mite populations cause bronzing of leaves and green twigs (Jeppson *et al.*, 1975). Kalaisekar *et al.* (2003a) studied quality changes as a result of rust mite attack on ëSathgudií sweet orange and Rangpur lime. Above authors reported that mite damaged fruits had less fruit weight, fruit size, juice volume and titrable acidity. Damaged fruits had more total soluble solids, sugars and ascorbic acid content than the unaffected normal fruits.

Seasonal abundance : Mites avoid direct sunlight and infest mostly undersurface of leaves and shaded areas on the fruit; infestation is generally more during warm and humid weather conditions. In summer mites prefer fruits than the leaves. Fruits on the upper branches are more preferred than those on lower branches.

Varietal susceptibility : Mites prefer lemon than other citrus species.

Chemical control : Monocrotophos and dicofol are next in order of effectiveness (Nagalingam and Savithri, 1983; Kalaisekar *et al*., 2003b).

Suggestions for proper management of mite pests on citrus:

1. Role of different biocontrol agents particularly fungi, viruses, phytoseiid mites need thorough investigation, since available information is scanty and inconclusive.
2. Economic injury levels of mites on different citrus species should be determined for planning timely protection measures.
3. Influence of glandular hairs/exudates/hairyness of leaves *etc*. on mite biology needs to be studied.
4. In orchards where mites appear regularly, use of broad - spectrum insecticides such as carbaryl and pyrethroids should be discouraged as these pesticides decimate mite predators and results in flare-up of phytophagous mites, alternatively these compounds can be used judiciously.
5. Use of specific acaricides should be encouraged against mite pests. Differential susceptibility of pesticidal compounds used on citrus needs to be ascertained against mite pests and their predators.
6. Attempts should be made to develop insecticides resistant strains of natural enemies as has been done in USA and European countries, where *Typhlodromus occidentalis* resistant to monocrotophos and other pesticides is used in biological control programmes.
7. Alternate host plants like castor, ëchandinií, ëamaltasí, *Melia* sp., which are heavily infested by mites, should not be allowed to grow in orchards as they harbour mites during off-season and aid in their survival and carry-over to fruit trees.
8. Citrus orchards should be irrigated judiciously, particularly during summer season to prevent water stress conditions and resultant flare up of mites.

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Acknowledgement

Photo	Source
Rind-disorder of kinnow (*Brevipalpus phoenicis)*	AINP on Agricultural Acarology, PAU, Ludhiana
Damage by *B. californicus*	http//www.fftc.agnet.org
Damage by *Panonychus citri*	Meyer, 1981
Damage by *Eriophyes sheldoni*	Meyer, 1981
Damage by *Polyphagotarsonemus latus*	http//www.fftc.agnet.org
Damage by *Phyllocoptruta oleivora*	http//agnet.org
Colony of *Eutetranychus orientalis*	AINP on Agricultural Acarology, PAU, Ludhiana
Brevipalpus phoenicis	http//www.fftc.agnet.org
Panonychus citri	Riehl *et al*., (1982) *Calif. Agric*., **36**
Polyphagotarsonemus latus	AINP on Agricultural Acarology, PAU, Ludhiana
Eriophyes sheldoni	Meyer, 1981
Phyllocoptruta oleivora	Meyer, 1981