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Management of black thrips in chilli in India: A review

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Abstract
India is the largest producer of chilli as cash crop in all over the world, contributing almost 43% of global production. Indian chilli is world famous for its colour and pungency levels. Thrips and mites are very common insect pests of chilli that can seriously harm chilli crop from the seedling stage to reproductive stage. In case of thrips, both in their adult and nymphal stages harm the chilli crop by drawing sap from the leaves, shoots, buds and fruits. Long-term thrips feeding will curl delicate leaves and buds, change the colour of the blossoms and fruit from bronze to black, and make the plant material unsellable.

Keywords: Chilli, thrips, integrated-pest-management

Introduction
Due to reports of the very polyphagous Black thrips (*Thrips parvispinus*) from a variety of farmed agricultural plants, there is considerable worry in India about this species. It is an Indonesian invasive bug species that Tyagi *et al*., 2015 [17] first discovered in a papaya crop in Bengaluru, Karnataka. T. *parvispinus* on *Chrysanthemum* sp. from Kerala has been reported by Rachana *et al*., 2022 [11]. Insect pests affecting capsicum and chilli crops have become increasingly prevalent in recent times. The invasive South East Asian thrips, or *Thrips parvispinus* (Karny), are a global pest that infests a variety of crops, including beans, pepper, potatoes, shallots, eggplant, papaya and strawberries. Additionally, ornamentals including Ficus, Dahlia, Dipladenia, Anthurium, and Chrysanthemum are infested by this parasite. It is currently known that this pest can also be found in Australia, France, Greece, Hawaii, Mauritius, Reunion, Spain, Tanzania, and the Netherlands, in addition to India.

Nature and damage symptoms
Adult *Thrips parvispinus* colonies are primarily found on blossoms and the underside of leaves, while larvae are limited to the leaf's underside. By ripping and sucking the sap from the plants, both larvae and adults harm the plants. Severe infestation inhibits fruit forming and development, slows plant growth, and causes flower drop, all of which contribute to production loss. In 2021, a significant infestation of T. *parvispinus* was noted in the chilli crop due to the North East monsoon's strong rainfall, as opposed to other thrips pests found in the country's southern regions. Deep scratches and punctures on the lower part of the leaves are signs of thrip damage. The leaf's underside becomes reddish brown due to infestation, while the leaf's upper side appears yellow. Yellow streaking and deformed leaf blade with necrotic regions are typical symptoms. Due to thrips scraping the petals, brownish streaks emerge on flower sections. Damage causes flowers to dry up and wither, which decreases fruit set. In severely infested fields, flowers drop is also observed, and thrips feed on the growing sections of the plant, which stunts the plant's growth. It was noted that a number of adults, both sexes, were feasting and resting in the nectariferous part of the chilli flowers. Due to thrips scraping the petals, there are brownish stains on them. Feeding on pollen may have an impact on pollination. Flower wilting and drying up and impact the fruit's setting are seen in severe cases.

Identifying characteristics of thrips species damaging chilli
Frankliniella scultzei
Every gender had full wings. Females are either brown with pronotum, tibiae, and tarsi being more pale and antennae brown with segmentation III–V yellow at base; fore wings yellowish with dark setae. Females are yellow with subtle shadings on tergites and antennal segmentation VI–VIII brown. Two sets of setae at the anterior margin of the metanotum; there are no campaniform sensilla. Dorsal surface of the hind coxae bearing a cluster of microtrichia. Veinal setae in two full rows on the forewing. Throughout the world, the common flower thrips occurs primarily in tropical and subtropical regions due to its extensive range (Vierbergen 1995) [18].
The life cycle consists of two dormant and non-feeding stages as well as two larval instars. The terms prepupa and pupa refer to the final two phases. Frankliniella schultzei females lay their eggs in the tissue of flowers. According to research done in Brazil the thrips life cycle under 24.5°C takes about 12.6 days to complete. The first and second larval instars, the prepupa and pupa, require an average of 2.5, 2.5, 1.2, as well as 2.1 days, respectively, during the four-day embryonic period. The average lifespan for an adult male and female is roughly 13 days.

Scirtothrips dorsalis
Both the sternites and the abdominal tergites have dark transverse antecostal ridges and a large number of microtrichia. The size of an adult chilli thrip is around 1 mm, and it has a pale yellow colour. Adults have light-colored bands across their abdomen and dark-colored wings. While other flower thrips are likewise pale yellow in colour, chilli thrips are about half the size of other flower thrips. There are three discal setae on the lateral microtrichial areas of the abdominal tergites. On segment VIII, the posteromarginal comb is finished. Straight cilia and a distantly light colour characterise the darkened forewings. In her lifetime, a single female can lay anywhere between

60 and 200 eggs (Dev, H.N. 1964) [3] the number of cycles that can occur annually depends on temperature and moisture content. In the plant tissue, on or near veins in the leaves terminal plant portions, and floral structures, males deposit their eggs. Parthenogenesis, the process by which females reproduce without mating, is a possibility. Over the course of life, pupation takes place in the soil.

Thrips palmi

Eggs are not visible to the unaided eye because they are placed within plant tissue, such as leaves, flowers, or fruits. There are two active feeding larval phases that can be found on any portion of the plant above ground, followed by two pupal stages. The latter are non-feeding and sedentary, but they will move if startled; the second-stage larvae typically descend to the ground to pupate, however on occasion they are discovered on the plant's aerial sections. The adults reappear above earth to lay eggs and feed after emerging. A single life cycle can be finished in as little as 17.5 days at 25°C. Tomato spotted wilt virus is one of the non-indigenous plant-based viruses of the Tospovirus genus that Thrips palmi has the ability to introduce and transmit (Nault, L. R 1997) [8].

Thrips parvispinus

The head and thorax of the adult T. *parvispinus* are brighter than the abdomen, and the body is brown to dark brown in color. Strong head with reticulation patterns and large, pigmented eyes. The morphology of compound eyes is not elongated. There were seven segments in the antenna, with fork-shaped sensing organs in the second and third segments. It lacks first ocellar setae, and the second setae are shorter than the third. There are two pairs of lengthy posteroangular setae and three pairs of shorter posteromarginal setae on the pronotum. On the metanotum, campaniform sensilla are absent. Conversely, tergite VX has a microtrichia comb. The ctenidia of the V-VIII tergite are part of the lateral, while the ctenidia of the tergite VIII are behind the spiracles. A wing's length exceeds the length of an abdomen. There was a full setae line at the vein front of the first and second wings, giving it a dark or darkened appearance with a pale base. T. parvispinus bodies vary in length, color, and width based on three different factors (Johari *et al*., 2014) [5].

The outbreak and economic importance

In 2021, there was an outbreak of this species in the states of Andhra Pradesh, Telangana, and Karnataka. The affected areas were severely infested, resulting in 70–100% damage. The state of Andhra Pradesh's Chilakaluripeta and Pratipadu mandals are where thrips on chili flowers were initially noticed in January 2021. From there, the phenomenon expanded to all of the state's chilli-growing regions (Sireesha *et al.*, 2021) [14]. Its significant infestation was also documented in Uttar Pradesh's eastern regions, specifically in the districts of Varanasi and Mirzapur. Over the course of four years, T. parvispinus's population increased alarmingly as a result of its extensive expansion, which entered lag phase. This has had an impact on the species' ability to adapt to a range of plant hosts and tendency to expand geographically within the country (Rachana *et al*., 2022) [11]. The widespread malformation, falling of chilli fruits, and blossom shedding result in a major loss of productivity in India. Andhra Pradesh's chilli growers estimated that their crops will lose one lakh rupees per acre (Anonymous, 2021b) [2]. In Indonesian agricultural conditions, T. parvispinus reduces chilli yield by 23–60%, according to Johari *et al*. (2014) [5].

Integrated pest management (IPM) approaches against thrips in chilli

There is a dearth of knowledge available globally on Thrips management. This is a presentation of the information that is currently accessible based on field studies that have been done and some ad hoc advice where the incidence is in severe proportions. Management of thrips from field condition is not easy.

Cultural methods

- To prevent the infestation from spreading, remove and destroy the badly affected plants.
- Deep summer ploughing to eradicate thrips and other pests' pupae and leftover stages.
- Using pest-free, healthy seedlings when planting.
- Conducting surveys in regions where chillies are grown as a means of continuously and methodically checking for infestation in new areas.
- There are lines of chilli pepper that are resistant to *Thrips parvispinus*. According to Maharijaya *et al*., (2011) [6], six pepper accessions—C. annuum AC 1979, C. annuum Bisbas, C. annuum Keystone Resistant Giant, C. annuum CM 331, C. baccatum no. 1553, and C. baccatum Aji Blanco Christal—were found to be good sources of resistance against T. parvispinus and F. occidentalis.
- It is necessary to apply recommended and balanced fertiliser applications and refrain from using nitrogenous fertilisers excessively (Sireesha *et al*., 2021) [14].
- Apply 2.5 t/ha of well-decomposed farm yard manure (FYM) or compost, supplemented with 2 kg/t of Metarhizium anisopliae or Pseudomonas fluorescens, in addition to the 25 to 30 t/ha recommended doses of farm yard manure.
- Avoid close spacing and stick to the prescribed spacing of 60 x 30 cm or 45 x 45 cm, as high density planting encourages the occurrence and growth of pests.
- Thrips can be biologically controlled by intercropping chilli with cowpea, maize/sorghum, and other crops at a 10:3:1 ratio as a barrier and reservoir crop against natural enemy multiplication.
- To stop thrips from reproducing in the soil, mulch with silver-coloured polythene sheets that are 25–30 microns thick.

Mechanical methods

- According to Murai *et al*., (2009) [7], T. *parvispinus* was more drawn to white colour traps compared to blue or yellow ones.
- More T. parvispinus adults are drawn to the blue and yellow sticky traps (Sireesha *et al*., 2021) [14].
- Choosing sprinkler irrigation over flood irrigation since the sprinklers' water jet spray prevents thrips from growing and multiplying.
- Gather and eliminate diseased crop residue, pull off off-season host weeds (*Parthenium* and *Abutilon* species) from the field, then set up 25–35 blue sticky traps per

acre for mass capturing right away following transplanting (Anonymous 2021a) [1].
- During the vegetative stage, heavily infested apical shoots should be nipped off and destroyed to eliminate thrips that are covering the apical sections.

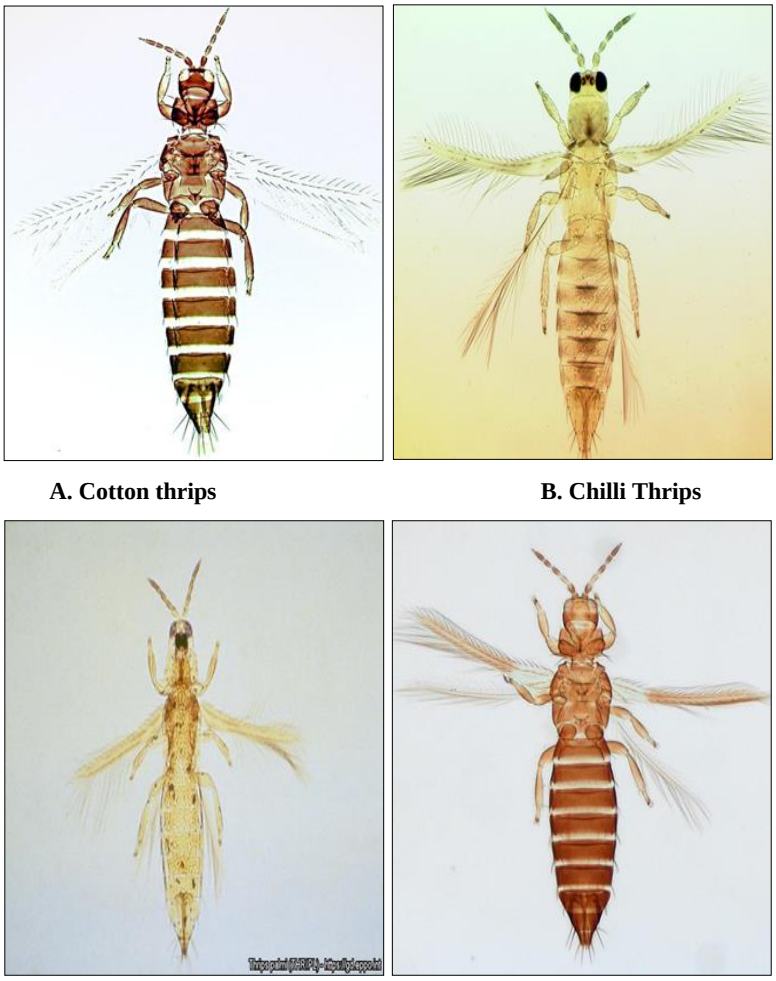
Physical methods
- *Frankliniella occidentalis* (Pergande), F. *intonsa*, T. *tabaci*, T. *palmi*, and T. *parvispinus* are the five different thrips species that die 100% when exposed to 60% CO2 atmospheres at 30°C (Seki and Murai 2012) [12].

Biological Methods
- Between 2003 and 2005, studies were carried out on thrips' natural enemies and a threshold for control to facilitate integrated pest management (IPM) of thrips (T. *parvispinus*) on sweet pepper grown under protection in tropical Indonesia. Potential natural enemies included the entomophagous fungus Lecanicillium lecanii and the two species of ladybird beetles, *Menochilus sensmaculatus* and *Coccinellella transversalis*.
- When M. *sexmaculatus* and V. *lecanii* were used, thrips infestation-related plant damage was decreased, and sweet pepper yields were comparable to yields from regular insecticide spraying twice a week.
- Thrips control thresholds were put in place, which prevented thrips from multiplying, kept plant damage below 10%, cut down on insecticide spraying frequency by about 90%, and preserved the production of sweet peppers (Prabaningrum *et al*., 2008) [9].
- Strategies for managing microorganisms with biopesticides: pseudomonas fluorescence, Spray with a focus on flowers and fruits (NBAIRPFDWD @ 20 g/l or Bacillus albus - NBAIR-BATP @ 20 g/l).
- Out of the many biopesticides examined, it was discovered that Azadirachtin (10000 ppm, 0.003%, 3 ml/liter) and Pseudomonas fluorescens (1% WP, 2 × 108 cfu/g, 4 g/L) were efficient in controlling newly introduced invasive thrips, T. parvispinus, that infested chillies.

Botanical control
- According to Rahardjo *et al*., (2021) [10], the Indonesian mahogany, Toona sureni (3.0%), fish poison bean, Tephrosia vogelii (2.5 and 3.0%), and eucalyptus oil (2.0%) all demonstrated greater than 30.0% efficacy during the vegetative stage and the lowest attack of T. parvispinus until 75 DAP. Additionally, all of these treatments produced the highest marketable flower yields of chrysanthemum.
- Additionally, standing crops should get an application of neem cake at a rate of 200 kg per acre. Application of pongamia oil, neem oil, or soap solution in heavily infested areas (Sridhar *et al*., 2021) [15].
- Applying a 2 ml/L sea weed (*Kappaphycus alvarezii*) extract spray will help plants become resistant to thrips' severe infestation.
- Application of commercial neem-based insecticide (Azadirachtin 3000 PPM) at a rate of 2 ml/L of water.

Legal control
- It has been observed that fruits and leaves that are more ripe have fewer thrips. Thus, it is improbable that fully ripe green chilli fruits will have thrips on them. Nonetheless, the petiole area of the chilli must be closely examined during regular phytosanitary inspections of the export shipments. Pods that are fully developed and only slightly wilted are harvested for red chilli export. The moisture content of collected pods is reduced to 10% by sun drying. During the harvesting and sun-drying procedures, any related insect pests are completely eradicated. Thus, T. *parvispinus* and all other thrips species do not pose a threat to the export of red chilies. It is important to keep an eye on pesticide residues by keeping track of the waiting period (DPPQ&S, 2022) [4].

Chemical control
- Sugano *et al*. (2013) [16] advised spraying papaya with a range of insecticides with different modes of action in order to lessen pest resistance.
- Spraying these areas is necessary because T. parvispinus feeds on the blooms and growing shoots of the papaya plant. Since young papaya leaves and fruit often have waxy surfaces and are difficult to wet, it is best to apply a surfactant, such as Latron B-1956, to improve the spreading and wetting of the leaves, giving you more control.
- After being exposed to a liquid phosphine solution at a 200 ppm concentration for one hour, T. parvispinus was completely eliminated (Setyawan *et al*., 2015) [13].
- The insecticides that are being rotated as ad hoc recommendations for the management of T. parvispinus outbreaks include Fipronil 80 WG @ 40g/acre, Fipronil 40% + imidacloprid @ 40g/acre, Cyantraniliprole @ 240ml/acre, Acetamiprid @ 40g/acre, and Spirotetramat @ 160g/acre (Sireesha *et al*., 2021) [14].
- Lower thrip counts (2.39 and 2.67 thrips/flower, respectively) were observed in plants sprayed with tolfenpyrad 15 EC @ 1 ml/L water and spinetoram 11.7 SC @ 1 ml/L water (Anonymous, 2022a).
- It is strictly forbidden to spray unlicensed agrochemicals, such as insecticides, plant growth regulators, nutrition mixes, etc.
- As a last resort, apply label claim insecticides sparingly and according to need, as specified in the attached Annexure.
- To stop the thrips resurgence (sudden outbreak), chemical insecticides with the same mode of action should be sprayed repeatedly. However, sub-lethal levels should be avoided.
- Spray Lambda Cyhalothrin 4.90%CS @ 500 ml in 500 L of water / ha at 5 days interval.
- Apply Emamectin benzoate5 % w/w + Lufenuron 40 % w/w WG @ 60 g in 500 L of water at 3 days interval.
- Apply Hexythiazox 3.5% + Diafenthiuron 42% WDG @ 650 g in 500 L of water at 7 days interval.
- Apply Methomyl 40 % SP @ 0.75 -1.12 kg in 500 - 1000 L of water at 5-6 days interval.
- Use Spinosad 45 % SC @ 160 g in 500 L of water at 3 days interval.



A. Cotton thrips **B. Chilli Thrips**

C. Melon thrips **D. Southeast Asia thrips**

Fig 1

Conclusion

In summary, integrated pest management (IPM) for controlling the chilli thrips complex places a strong emphasis on integrated, sustainable methods that reduce environmental impact while controlling pest populations. Growers can establish long-term control and reduce the risks associated with pesticide resistance and environmental harm by combining cultural practices, biological controls, and targeted chemical treatments. Growers often notice yield boosts of 10% to 30% or more after applying effective thrips management strategies, however exact percentage increases can vary.For the successful management of the species, it is recommended to approach the Thrips complex using an integrated pest management strategy that includes a range of environmentally friendly tools, such as host plant resistance, biological control options like entomopathogens, physical and mechanical control measures, the use of environmentally friendly insecticides etc.

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