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GLOBAL STATUS OF *THRIPS PARVISPINUS* (KARNY, 1922), AN INVASIVE PEST

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ABSTRACT

Thrips are important group of sucking pests which cause significant economic losses both as pests and vectors of serious plant viruses in several horticultural crops. Recently an outbreak of *Thrips parvispinus* has been reported from southern states of India (Andhra Pradesh, Karnataka and Telangana) especially on chilli crop causing 70-100 per cent damage. *T. parvispinus*, a member of "*Thrips orientalis* group", is a widespread pest species of quarantine importance and designated as one of the pest species of South East Asia. *T. parvispinus* has displaced *T. palmi* in Indonesia indicating its competitive ability in displacement of other species in the crop ecosystem. Successful quarantine interceptions made throughout the world against this pest shows the importance of interceptions in avoiding the entry of invasive pests in to any country. Despite existence of the quarantine provisions, recent invasion of various exotic pests like South American tomato moth, rugose spiralling white fly, fall armyworm *etc*. into India in quick succession is a concern particularly under globalisation situation. Considering the seriousness of the damage caused by the invasive pest in India in the recent past, an attempt was made in this review to present the status of *T. parvispinus* at national and global level including its identification, taxonomic status, host range, development and biology, extent of damage and various management strategies. Importance of various IPM tools to be explored for the management of this invasive thrips is also discussed in the review.

Keywords: Chilli, invasive, *parvispinus,* polyphagous, thrips

Thrips are important group of sucking pests which cause significant economic losses both as pests and vectors of serious plant viruses in several horticultural crops. There are reports on the outbreak of sucking pests like thrips in different regions due to changes in crop production patterns, pesticide usage and climate change. Recenty an outbreak of *Thrips parvispinus* has been reported from southern states (Andhra Pradesh, Karnataka and Telangana) especially on chilli crop causing 70-100 per cent damage. Considering the seriousness of the damage caused by the invasive pest, an attempt is made in this paper, to present the status of *T. parvispinus* at national and global level including its identification, host range, extent of damage and management strategies.

The genus Thrips is one of the largest genera of the insect order Thysanoptera in the family Thripidae, with 295 species worldwide, of which 44 species are reported from India (Rachana and Varatharajan, 2017; Rachana *et al*., 2018). Species of this genus are important pests causing damage directly by feeding and egg laying or indirectly by vectoring different pathogenic tospoviruses on economically important crops (Marullo and Mound, 2002). They cause damage by piercing and sucking the sap from different parts of the plant by their well-developed left mandible. The gravid females oviposit the eggs in to the plant tissues with the help of saw-like ovipositor (Ananthakrishnan, 1984). Their role as pollinators has also been documented on various tropical and subtropical crops (Varatharajan *et al.,* 2016). As insect vectors, thrips are sole transmitters of Tospoviruses (genus Tospovirus, family Bunyaviridae) affecting a number of plant species belonging to unrelated plant families across the globe (Riley *et al.,* 2011).

1.1. About *T. parvispinus*

T. parvispinus, a member of "*Thrips orientalis* group" (Mound, 2005), is a widespread pest species of quarantine importance and designated as one of the pest species of South East Asia. *T. parvispinus* has been documented from Thailand to Australia (Mound and Collins, 2000). It is reported on papaya in Hawaii, *Gardenia* sp. in Greece, vegetable crops like Capsicum, green beans, potato, and brinjal from other countries (Murai *et al.,* 2009). Occurrence of this

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species in India has been first reported by Tyagi *et al.,* (2015) on papaya from Bangalore. Present status of *T. parvispinus* globally is discussed in this review.

2. Taxonomic Identity of *T. Parvispinus*

Species

Thrips parvispinus (Karny, 1922)

Taxonomic history

Thrips (*Isoneurothrips*) *taiwanus* Takahashi, 1936

Isoneurothrips pallipes Moulton, 1928

Isoneurothrips jenseni Karny, 1925

Isoneurothrips parvispinus Karny, 1922

Common name (s)

Taiwanese thrips, South East Asian Thrips, Tobacco thrips (?)

Present taxonomic position

Family: Thripidae Stephens, 1829

Subfamily: Thripinae (Stephens) Karny, 1921

Genus: *Thrips* Linneaeus, 1758

3. Identification

Females and males differ in size and colour. Females are nearly 1 mm long, with brown head and prothorax, yellowish brown meso- and metathorax and black abdomen; forewings are dark, with light coloured base; the third antennal segment and the base of the fourth and fifth segments are light coloured (either yellow or white). Males are 0.6 mm long and evenly yellow.

The following features segregate *T. parvispinus* from other known species of the genus Thrips.

a. Ocellar pair III at the anterior margin of ocellar triangle; postocular setae III shorter than postocular setae I and IV.

b. Metanotum reticulate medially; median setae long and placed well behind the anterior margin; campaniform sensilla absent.

c. First and second vein of forewing with continuous row of setae (Figures 1-3).

d. Posterior margin of tergite VIII without comb.

e. Abdominal sternites III-VI with discal setae, but absent on II and VII (Mound, 2005; Tyagi *et al.,* 2015; Mound *et al.,* 2016, Rachana *et al.,* 2018).

3.1. Taxonomic Description of the species

(Source: Factsheet - *Thrips parvispinus* http://thripsnet.zoologie.uni-halle.de/key-server-neu/data/0a0b0a0e-0d03-4106-8306-08060a080902/ media/Html/ Thrips%20 parvispinus.html)

Typical key character states of *Thrips parvispinus* are

Coloration and body sculpture

i. Body color: mainly brown to dark brown

Surface of head, pronotum: with transverse sculpture

ii. Legs: yellow

3.1.1. Antennae

Number of antennal segments: 7

Antennal segment I: without any setae on dorsal apical margin

Antennal segment III: yellow

Length of antennal segment III and IV: antennal segment III similar in length to segment IV

Form of sense cones on antennal segments III and IV: emergent and forked on segments III and IV

3.1.2. Head

Distance between bases of ocellar setae III: greater than width of first ocellus

Head: not prolonged in front of compound eyes

Ocellar setae I: absent

Length of ocellar setae II: shorter than setae III

Ocellar setae III: arising on anterior margin of, or in front of ocellar triangle

Number of ocellar setae: 2 pairs

3.1.3. Prothorax

Number of pairs of long posteroangular setae: 2

Number of pairs of posteromarginal minor setae: 3-4

3.1.4. Metathorax

Metanotalcampaniformsensilla: absent

Reticulations of metanotal sculpture: prominent median reticulated sculpture

Metanotal median setae: S1 behind anterior margi

3.1.5. Wings

Fore wing veins: present

Fore - and hind wing surface: covered with microtrichia

Fore and hind wings: present, more than half as long as abdomen (macropterous)

Apex of fore wing: with prominent terminal setae

Fore wing anterior margin (costal vein): with setae and cilia but cilia longer than setae

Fore wing clavus - number of marginal setae: 5

Fore wing clavus - terminal veinal seta: longer than subterminal seta

Fore wing costal fringe cilia: arising at anterior margin of wing

Fore wing first vein: distinct from costal vein

Fore wing first vein setal row: complete, with setae closely and uniformly spaced

Fore wing second vein setal row: complete, setae uniformly spaced

Fore wing shape: mainly parallel sided or margins run continuously towards each other

Fringe cilia on posterior margin near apex: distinctly wavy (undulated)

Shape of fore wing apex: with mainly posterior margin curved to join anterior margin

Fore wing extreme apex color: dark

Fore wings: uniformly dark or shaded, but with base or sub-base pale

3.1.6. Legs

Mid and hind tarsi: with two segments

Color of fore tarsi: pale or yellow, sometimes apical shaded or brown

3.1.7. Abdomen

Pleurotergaldiscal setae: absent

Sternite II: with marginal setae but no discal setae

Number of discal setae on sternites III to VI: 6-12 (13)

Sternites IV, V and VI: with marginal setae and discal setae medially

Pairs of posteromarginal setae on sternites V and VI: 3

Sternite VII median posteromarginal setae S1: arising in front of posterior margin

Sternite VII: with marginal setae but no discal setae

Number of lateral marginal setae on tergite II: 4

Sculpture of tergites II to VIII: with one or without transverse lines of sculpture between median pair of setae S1

Tergites II to VII median setal pair: no more than 0.3 as long as median length of tergite

Craspedum on tergites IV to VI: absent

Tergites IV and V median setal pair: shorter than distance between their bases

Markings on tergites IV to VI: without shaded areas medially

Tergites V to VII: with ctenidia laterally

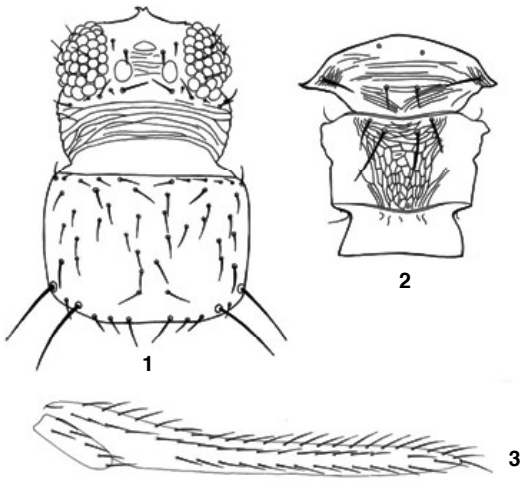
Craspedum on tergite VIII: without craspedum medially and toothlike microtrichia laterally

Tergite VIII ctenidia: posteromedial to spiracle

Color of tergites IX and X: dark or brown

Tergite X: not tubular, longitudinally incomplete

Setae on abdominal tergite X: all setae slender



***Figures 1-3. T. parvispinus*, female**
(1) head and pronotum; (2) meso-andmetanotum, (3) fore wing **Source:** Tyagi *et al.,* (2015)

4. Similar or related species to *T. parvispinus*

Species of the Genus Thrips (Thysanoptera, Thripidae) from the Afro-tropical region were described and identification keys were given by Mound (2010). *T. parvispinus* is very similar to other *Thrips* species - like *Thrips orientalis*. *Thrips parvispinus* has discal setae on sternites III-VI but not on sternite VII, and no discal setae on pleurotergites (*Thrips australis*, *Thrips microchaetus*, *Thrips subnudula* and *Thrips tenellus*, all of them have sternites III-VII with at least 1 pair of discal setae and pleurotergites with discal

setae; *Thrips acaciae*, *Thrips brevisetosus*, *Thrips florum,Thrips gowdeyi*, *Thrips hawaiiensis* and *Thrips simplex*, all of them have sternites III-VII with at least 1 pair of discal setae and pleurotergites without discal setae; *Thrips nigropilosus*, *Thrips palmi*, *Thrips pusillus* and *Thrips tabaci*, all of them have sternites and pleurotergites without discal setae).

Thrips parvispinus differs from *Thrips orientalis* in having sternites III-VI with 6-13 discal setae in an irregular row, metanotal equiangular reticulations rarely with faint internal sculptured markings, brown fore wings with base sharply paler, on fore wing clavus the terminal veinal seta is longer than subterminal seta, and the fore wing first vein setal row is complete. *Thrips orientalis* has sternites III-VI with no more than 6 discal setae placed laterally, metanotal equiangular reticulations with many conspicuous internal sculptured markings, brown fore wings only with small white spot near veinal fork, on fore wing clavus the terminal veinal seta is shorter than subterminal seta, and the fore wing first vein is highly variable on distal half, from almost complete to only 2 setae medially and 4 distally. Outside this group, the species is similar to *Thrips australis* in having a metanotal median sculpture with mainly equiangular reticulation, the fore wing first vein with setal row complete, and the comb of tergite VIII is present laterally and absent medially.

5. Hosts and Damage

5.1. Hosts

Thrips parvispinus is a polyphagous pest with a wide range of hosts varying across its geographic distribution (Table 1). It is a pest mainly on fruit, vegetable and ornamental crops, such as coffee, *Gardenia* sp., papaya, chilli pepper, sweet pepper, potato, tobacco, *Vigna* sp., green bean, strawberry, shallots, watermelon and other cucurbits (EPPO, 2001; Azidah, 2011; Hutasoit *et al.,* 2017; Moritz *et al.,* 2013; for an extensive list see Sartiami and Mound, 2013). It is reported on papaya in Hawaii, *Gardenia* sp. in Greece, vegetable crops like Capsicum, green beans, potato, and brinjal from other countries (Murai *et al.,* 2009). In Europe it is found on ornamentals in green houses, Citrus, *Dipladenia*, *Ficus benjamina*, Gardenia, Gerbera and Schefflera (Lacasa *et al.,* 2019). In regions where the species has been long established, the crops most affected are papaya, peppers, potatoes, egg plants, beans, shallots, crotalaria, *Vigna* sp., coffee, cucumber, tobacco (Hutasoit *et al.,* 2017). It is most damaging to papaya

Table 1. Host range of *T. parvispinus* across the world

Hosts Reported	Reference
Black Jack (*Bidens pilosa*), coffee, *Gardenia* sp., papaya, chilli pepper, paprika, potato, tobacco, *Vigna* sp., green bean, strawberry, egg-plant, watermelon and other cucurbitaceae	(Factsheet - *Thrips parvispinus* (uni-halle.de))
Papaya	Tyagi *et al.,* 2015
Papaya, peppers, potatoes, eggplants, beans, shallots, crotalaria, vigna, coffee, cucumber, tobacco	Hutasoit *et al.,* 2017
Anthurium, chrysanthemum, dahlia, dipladenia, gardenia and ficus	NPPO, 2019
Chilli, weed species like Parthenium, *Amaranthus* sp., *Axonopus* sp., *Ageratum* sp. *Alternanthera* sp. *Thunbergia* sp, foliage of neem and pongamia	Nagaraju *et al.,* 2021
Pepper, anthurium and hoya	Johari *et al.,* 2014
Chilli, capsicum, mango, cotton, drumstick, cucumber, bottle gourd, bitter gourd, beans, marigold, chrysanthemum, watermelon, coccinea, brinjal *etc*.	Sridhar *et al.,* 2021 (In press)

in Hawaii and Indonesia, peppers and other solanaceous crops in Indonesia and ornamentals in Europe and Indonesia. Also reported as a pest from India on papaya plantations (Tyagi *et al.,* 2015). Ornamental plant *Dahlia rosea* Cav. has been reported as new host for the quarantine thrips, *T. parvispinus* from Karnataka, India (Rachana *et al*., 2018)

5.2. Damage

The damage symptoms include deep punctures and scratches on under- side of the leaves, due to sucking of sap. Underside of the leaf turns reddish brown and upper side of the leaf looks yellowish. Distorted leaf lamina has necrotic areas and yellow streaking. On floral parts, scraping on petals is observed resulting in brownish streaks on petals. Drying and withering of flower affected fruit set. Growth of the plant also will be affective as it feeds on growing portions of the plant. Significant flower drop is also observed in severely infested fields. Several adults, both male and female were observed feeding and hiding in the base of the chilli flowers (Plate 1) (Sireesha *et al.,* 2021).

Plate 1. Female (black and large) and Male (yellowish and small) adults of *T. parvispinus* feeding on chilli flowers

T. parvispinus is a dangerous insect pest that attack and damage chilli plants. These pests damage plants by sucking and whittling. The damage, which was caused by thrips in Bandung and Bogor Regency of Indonesia ranged 10-46% (Johari *et al*., 2014). Major damage is caused by direct feeding of larvae and adults on leaves and growing buds, but at least in papaya, tissue damaged by the thrips may be secondarily and independently infected by a saprophytic fungus, *Cladosporium* (Lim, 1989). It also damaged ornamentals such as Dahlia, Chrysanthemum, Gardenia, Dipladenia and Ficus. In Florida, *T. parvispinus* was found only on Anthurium and Hoya growing in greenhouses. Damage to Anthurium was most evident on leaves. Varieties Cyrano, Charade White, Zizou and Sierra White are most susceptible to attack. In Hoya, thrips attack eventually kill the buds.

5.3. Vector capacity

Tobacco streak virus (TSV), mechanical transmission of *Cladosporium oxysporum* causing bunchy-top, *i.e*. malformed leaves and shot holes on new flushes (Lim, 1989). However, *Thrips parvispinus* is not known to transmit tospoviruses.

6. Development and Biology

Female insert eggs into leaves. After four to five days, larvae hatch and feed on leaves and flowers. Larvae go through two molts in four to five days, mature and pupate. The two pupal stages last two to three days. Reproduction is sexual and on an average females lays 15 eggs. Mated females live nine days. Adult males live six days (Hutasoit *et al*. 2017). Total life cycle of *T. parvispinus* is completed in 13 - 14 days.

According to the biological and demographic information recorded by the Hutasoit *et al.* (2017), there are five phases of immature stages of *T. parvispinus, i.e.,* eggs, two nymphal instars, prepupa, and pupa with their stadia 4.79, 1.36, 3.54, 1.08 and 1.96 days respectively. The preoviposition period of the insect was 1.11 days, life cycle was 13.68 days, female longevity was 8.55 days, male longevity was 6.00 days, and fecundity was 15.33 eggs per female. The population development of *T. parvispinus* followed type III of survivorship curve with intrinsic rate of increase of 0.15 individuals per day per female, net reproductive rate was 5.71 individual per female per generation with generation time of 11.49 days and doubling time was 4.57 days. The average developmental period of the pre-adult phase or the stage of becoming imago of *T. parvispinus* lasted for 12.97 and 12.57 days in males and females, respectively. It was also observed that *T. parvispinus* has metamorphosis transition between paurometabola and holometabola (Borror *et al*., 2005). Murai *et al.* (2010) observed mean fecundity and mean generation

time at 20°, 25° and 30°C were 50, 69, and 56 eggs and 37.6, 24.8 and 18.8 days, respectively. Intrinsic rate of natural increase at 20°, 25° and 30°C was 0.18, 0.24 and 0.37, respectively.

7. Establishment and Distribution

T. parvispinus is known from Thailand and Malaya to New Guinea and northern Australia, also Hawaii, Micronesian Islands, and Greece. It has widespread in Southeast Asia to northern Australia and Solomon Islands (Palmer, 1992), extending its area of distribution to the north (Yunnan – China) (Zhang *et al*., 2011), the Philippines (Reyes, 1994) and Taiwan (Mound and Masumoto, 2005) and India (Tyagi *et al*., 2015; Rachana *et al*., 2018). It has been reported from Hawaii in 2006 (Sugano *et al.,* 2013). In Africa, it has been recorded from the French overseas department La Reunion (Bournier, 2000), from Mauritius (Mound, 2010) and from the mainland in Tanzania (Dar-el-Salaam) and Uganda (Kampala) (Moritz *et al*., 2013). In Europe, it has been reported from Greece in 1998 (Mound and Collins, 2000), Spain in 2017 (Lacasa *et al.,* 2019) and from France in 2018 (EFSA, 2019).

Sartiami *et al.* (2011) had recorded the information regarding the morphological diversity of *T. parvispinus* at three different altitudes which include Cirebon (< 30 m asl), Bogor (300 - 400 m asl), and Cianjur (> 1200 m asl). It was revealed that the body length, thoracic width, and wing length of the highland thrips were longer than those of the mid and lowland thrips. Changes in the color of head was also observed, dominant color for the area Cianjur was dark brown (chocolate dark) on the head, olive brown (olive green chocolate) and dark brown (dark brown) for the thorax, and dark brown for abdominal part. At lower level, *i.e*, Bogor and Cirebon, colors dominant for the head and thorax is olive brown while the abdomen is dark yellowish brown (dark yellowish brown) (Cirebon) and dark brown (dark brown) (Bogor).

In Europe factors affecting the establishment of T. *parvispinus* was studied. Based on the similarity in feeding biology to *Thrips tabaci* and in abiotic and biotic requirements to *Thrips palmi*; it was concluded that the species will probably be able to survive indoors in protected crops throughout the EU and possibly outdoors in some parts of Southern Europe. EFSA_Panel_on_Plant_Health (2019) concluded for *Thrips palmi* that "only a small area of the EU provides climatic conditions where establishment may be possible outdoors". They further observed that this may also be the case for *T. parvispinus.*

Spread of thrips: Thysanoptera, including *Thrips parvispinus*, can especially be spread by trade/ movement of infested plants. No data are known about its ability to spread by natural dispersal (by flight, wind), but most likely this will be very similar to other thrips pests already present (i.e., they may disperse by wind over several hundreds of metres when temperatures are high; the probability of natural spread between glasshouses may be low especially in cooler areas and during cooler periods).

Species replacement capabilities: Sridhar *et al.* (2021) observed that in T. *parvispinus* outbreak areas in India, it has displaced the well-established chilli thrips, *Scirtothrips dorsalis* in chilli ecosystems from the states of Andhra Pradesh, Karnataka and Telangana. However, they opined that systematic monitoring is to be taken up to establish whether it is an ecological phenomenon of species displacement is of seasonal importance, whether it is reversable or irreversible. In Indonesia, *T. parvispinus* has replaced *Thrips palmi* as the key thrips on vegetables (Murai *et al.,* 2010).

Interceptions of *T. parvispinus*

Interceptions have been reported on produce such as cut flowers and vegetables, indicating its potential to spread via trade. In the Netherlands *T. parvispinus* has been intercepted (as *T. taiwanus*) as early as 1996 on a consignment of Gardenia cut flowers from Indonesia and on shipments containing various cut flower species from Asia since then. Other European countries have intercepted *T. parvispinus* several times during the past 2 decades: - in the UK on Gardenia from Indonesia (Mound and Collins 2000) and on Orchidaceae from Malaysia (Collins, 2010), - in Switzerland on *Rosa* spp. from Thailand (January 2013) and on *Momordica charantia* from Sri Lanka in 2016 (Andreas von Felten, Swiss Plant Protection Service SPPS, pers. comm., 2019.) and on *Solanum aethiotipum* vegetables from Uganda (EPPO, 2016; EU, 2016) - in France it was intercepted on *Momordica charantia* vegetables from Cambodia (EPPO, 2014). In Japan it has been intercepted on *Heliconia* shipped from Mauritius. Although most interceptions have been

made on cut flowers and vegetables, *T. parvispinus* has been intercepted on plants for planting in the Netherlands, on *Ixora* pot plants from Thailand in 2005, and on a Whrightia pot plant from Indonesia in 2013 (Quick scan *Thrips parvispinus*, 2019).

8. Outbreak of *T. parvispinus* from India

Outbreak of this species was reported from the states of Andhra Pradesh, Telangana and Karnataka during 2021 causing 70-100 per cent damage in severely infested fields (Plate 2). Thrips on chilli flowers were first noticed in Chilakaluripeta and Pratipadu mandals of Guntur district of Andhra Pradesh state, during January, 2021 and subsequently its spread was noticed in all chilli growing areas in the state (Sireesha *et al.,* 2021). The pest is also infesting the red chilli crop in districts of Telangana and Andhra Pradesh. The infestation occurs at flowering stage and affecting the fruit development. (https://www.thehindu business line.com/markets/commodities/pests-attack-chilli-crop-in-telangana-ap/article 37917372.ece). It also inflicts injury to ornamentals *viz*., Anthurium, Chrysanthemum, Dahlia, Dipladenia, Gardenia and Ficus (NPPO, 2019). Flowers of weeds species *viz*., Parthenium, *Amaranthus* sp., *Axonopus* sp., *Ageratum* sp. *Alternanthera* sp. *Thunbergia* sp. found in chilli fields and foliage of neem and pongamia bordering chilli fields were also found infested with *T. parvispinus* (Nagaraju *et al.,* 2021). The invasion of *T. parvispinus* attained lag phase and resulted in its population increasing alarmingly within a short duration of four years, and that has influenced their adaptability on diverse plant hosts, in addition to their tendency to expand geographical range within the country (Rachana *et al.,* 2021).

Plate 2. Team visiting the Severely infested fields of chilli due to *T. parvispinus* in Telangana state

9. Management

Very limited information is available regarding management of *T. parvispinus* worldwide. The available information based on field studies conducted and some of the ad hoc recommendations made where the incidence is in severe proportions is presented here.

9.1. Cultural measures

- Removal and destruction of the severely infested plants to stop further spread
- Use of healthy and pest free seedlings for planting
- Constant systematic monitoring and inspection for its infestation in new areas through surveys in chilli growing areas
- Chilli pepper lines resistant to *Thrips parvispinus* have been identified. 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 identified as good sources for resistance against *T. parvispinus* and *F. occidentalis* (Maharijaya *et al*., 2011)
- Nitrogen and potash fertilizers can be applied in five splits during crop growth
  a. Organic fertilizers like FYM@10 tones/ acre
  b. Neemcake @200kg/acre
  c. Vermicompost @2tonnes/acre
  d. Azospirillum and phosphate solubilizing bacteria each @2kg/acre, in order to maintain proper nutrition to the plants
- Avoiding excessive use of nitrogenous fertilisers and application of recommended and balanced use of fertilizers needs to be followed (Sireesha *et al.,* 2021).

9.2. Physical/ Mechanical measures

- Murai *et al.* (2010), observed T. *parvispinus* was more attracted to white rather than blue or yellow colour traps. Others have observed Blue and yellow sticky traps attracting more *T. parvispinus* adults (Sireesha *et al.,* 2021)
- Laboratory studies indicated that they are susceptible to spinosad and not to acetamiprid (Murai *et al*., 2010). Exposure to 60% CO_2 atmospheres at 30°C results in 100% mortality

of five different thrips species, *Frankliniella occidentalis* (Pergande), *Frankliniella intonsa* (Trybom), *Thrips tabaci* Lindeman, *Thrips palmi* Karny, and *Thrips parvispinus* Karny (Seki and Murai, 2012)

9.3. Botanicals

- Application of neem cake @ 200 kg /acre even on the standing crop
- Use of neem oil, pongamia oil or soap solution in heavily infested sites. Judicious use of chemical insecticides as well as fertilizers as per the Package of Practices (POP) recommended by the local regions/Universities/Departments. (ICAR- NBAIR, Pest alert, 2021)

9.4. Biological control

- Research on natural enemies of thrips and a control threshold to support integrated pest management (IPM) of thrips (*T. parvispinus*) on sweet pepper in protected cultivation in tropical conditions in Indonesia was conducted in 2003 and 2005. Two species of ladybird beetles, *Menochilus sexmaculatus* and *Coccinella transversalis*, and an entomophagous fungus, *Lecanicillium lecanii* were identified as potential natural enemies. The use of *M. sexmaculatus* and *V. lecanii* suppressed plant damage due to thrips infestation and resulted in sweet pepper yields that were equal to yields where insecticides were routinely sprayed twice weekly. The implementation of thrips control thresholds suppressed the thrips population, maintained plant damage below 10%, and reduced the frequency of insecticide spraying by approximately 90%, and sustained sweet pepper yield (Prabaningrum *et al*., 2008)
- Microbial biopesticide based management practices- *Pseudomonas fluorescence*- NBAIRPFDWD @ 20 g/l or Bacillus albus - NBAIR-BATP @ 20 g/l spray focusing on flowers and fruits

9.5. Chemical management

Sugano *et al*. (2013) suggested to spray papaya with rotation of chemicals with different mode-of action classes to minimize pest resistance. Spray should be targeted at the flowers and growing shoot of the papaya plant, as *T. parvispinus* lives and feeds there. A surfactant such as Latron B-1956 should be used to improve the spreading and wetting of the leaves and thus provide better control as young papaya leaves and fruit tend to have waxy surfaces and can be hard to wet. Application of azadirachtin 10,000 ppm @ 1 ml/L before flowering either as single application or in combination with recommended chemicals after thorough mixing in order to manage the resistance development. Rotation of insecticides *viz.,* fipronil 80WG @ 40g/acre/ fipronil 40% + imidacloprid 40% @ 40 g/acre/ cyantraniliprole 10% @ 240ml/acre/ acetamiprid 20SP @ 40 g/acre/ spirotetramat 150 OD @ 160 ml/acre is being suggested as ad hoc recommendation for the management of outbreak of *T. parvispinus* (Sireesha *et al.,* 2021). Anitha Kumari *et al.,* (2021) also recommended on ad hoc basis spraying of fipronil 80% WG @ 0.2 g/lit or cyantraniliprole @ 1.25 ml/lit or acetamaprid @ 0.2 g / lit or spinosad @ 0.3 ml/lit water as sequential sprays at weekly interval to manage *T. parvispinus.*

CONCLUSION

Regular monitoring of invasive thrips, *T. parvispinus* on different crops in chilli growing areas is essential to take up timely interventions and to contain its further spread. Being an invasive pest and highly polyphagous, bioecology studies helps in understanding the behaviour of the pest and in planning effective IPM. Community approach in pest management helps in better management of thrips particularly when the incidence is flaring up at large scale. As the pest is invasive, there is a need to develop baseline toxicology data regarding its susceptibility for different insecticides recommended for thrips management for planning Insecticide Resistance Management strategies, as a part of IPM. Under-standing the reasons for the outbreak of *T. parvispinus* under changing climatic conditions and other ecological and genetic factors helps in preparedness in case similar conditions happens in future. Overall, an integrated pest management approach for tackling *T. parvispinus* by including various eco-friendly tools *viz.*, host plant resistance, biological control options like entomopathogens, physical and mechanical control measures, use of eco-friendly insecticide molecules *etc.* are suggested followed for its effective management.

REFERENCES

Ananthakrishnan, T.N. 1984. Bioecology of thrips, Indira Publishing House, Michigan, USA, 233pp.

Anitha Kumari, D., Bhasker, K and Suresh, V. 2021. A new invasive chilli thrips (*Thrips parvispinus*) in Telangana State. Insect Environment. 24(4): 520-522.

Azidah, A. A. 2011. Thripidae (Thysanoptera) species collected from common plants and crops in Peninsular Malaysia. Scientific Research and Essays. 6(24): 5107-5113.

Borror, D. J., Triplehorn, C.A and Johnson, N.F. 2005. An Introduction to the Studies of Insects. 7th ed. United States of America: Brooks/Cole

Bournier, J.P. 2000. Les Thysanoptères de l'île de la Réunion: Terebrantia. Bulletin de la Société entomologique de France 105: 65-108.

Collins, D.W. 2010. Thysanoptera of Great Britain: A revised and updated checklist. Zootaxa 2412(2412):21-41. DOI: 10.11646/zootaxa. 2412.1.2

EFSA, 2019. Emerging risks exchange network. Minutes of the 21st meeting, 10–11 April 2019, Parma, Italy.

EFSA_Panel_on_Plant_Health, Bragard, C., Dehnen, S.K., Di, S.F., Gonthier, P., Jacques, M.A., Jaques, M.J.A., Fejer, J.A., Magnusson, C.S., Milonas, P., Navas, C.J.A., Parnell, S., Potting, R., Reignault, P.L., Thulke, H.H., Van der Werf, W., Vicent, C.A., Yuen, J., Zappalà, L., Malumphy, C., Czwienczek, E and MacLeod, A. 2019. Pest categorisation of *Thrips palmi*. EFSA Journal, 17(2), e05620. Available online: https://doi.org/10.2903/j.efsa.2019.562

EPPO, 2001. Mini datasheet on *Thrips parvispinus* (Thysanoptera: Thripidae) - A south-east Asian thrips. https://gd.eppo.int/download/doc/1100_minids_THRIPV.pdf [accessed July 31, 2019]

EPPO Reporting Service no. 05 - 2014. EPPO report on notifications of non-compliance. 2014/091. https://gd.eppo.int/reporting/article-2811 [accessed July 31, 2019]

EPPO Reporting Service no. 10 - 2016. EPPO report on notifications of non-compliance. 2016/183. https://gd.eppo.int/reporting/article-5928 [accessed July 31, 2019]

EU, 2016. Interceptions of commodities imported into the EU or Switzerland with harmful organism(s). Europhyt September 2016. [accessed July 31, 2019] https://ec.europa.eu/food/sites/food/files/plant/docs/ph_biosec_europhyt-interceptions-2016- 09.pdf

Factsheet - Thrips parvispinus (uni-halle.de) https://www.thehindubusinessline.com/markets/commodities/pests-attack-chilli-crop-in-.telangana-ap/article37917372.ece

Hutasoit, R.T., Triwidodo, H and Anwar, R. 2017. Biology and demographic statistic of *Thrips parvispinus* Karny (Thysanoptera: Thripidae) in chili pepper (*Caspicum annuum* Linnaeus). Indonesian Journal of Entomology, 14: 107-116.

ICAR-NBAIR. Pest Alert: Invasive thrips, *Thrips parvispinus* (Karny) threatening chilli cultivation in India.

Johari, A., Herlinda, S., Pujiastuti, Y., Irsan, C and Sartiami, D. 2014. Morphological and genetic variation of *Thrips parvispinus* (Thysanoptera: Thripidae) in chilli plantation (*Caspicum annuum* L.) in the lowland and highland of Jambi Province, Indonesia. American J. Bio Sci., 2: 17-21.

Lacasa, A., Lorca, M., Martinez, M.C., Bielza, P and Guirao, P. 2019. *Thrips parvispinus* (Karny, 1922), un nuevo trips en cultivos de plantas ornamentales. Phytoma Espana 311: 62-69.

Lim, W.H. 1989. Bunchy and malformed top of papaya cv. Eksotika caused by *Thrips parvispinus* and *Clodsporium oxysporum*. Mardi Research Journal, 17: 200-207.

Maharijaya, A., Vosman, B., Steenhuis-Broers, G., Harpenas, A., Purwito, A., Visser, R.G.F and Voorrips, R.E. 2011. Screening of pepper accessions for resistance against two thrips species (*Frankliniella occidentalis* and *Thrips parvispinus*), Euphytica 177: 401-410.

Marullo, R and Mound, L.A. 2002. Thrips and Tospviruses: Proceedings of the 7th International Symposium on Thysanoptera. Australian National Insect Collection, Canberra.

Moritz, G., Brandt, S., Triapitsyn, S and Subramanian, S. 2013. Identification and information tools for pest thrips in East Africa. CBIT Publishing, Queensland.

Mound, L.A. 2005. The *Thrips orientalis* group from South-east Asia and Australia: some species identities and relationships (Thysanoptera: Thripidae). Australian Journal of Entomology, 44: 420-424.

Mound, L.A. 2010. Species of the genus Thrips (Thysanoptera, Thripidae) from the Afro-tropical region. Zootaxa 2423: 1-24.

Mound, L.A.D.W and Collins, D.W. 2000. A South East Asian pest species newly recorded from Europe: *Thrips parvispinus* (Thysanoptera: Thripidae), its confused identity and potential quarantine significance. Journal of European Entomology, 97: 197-200.

Mound, L.A and Masumoto, M. 2005. The genus Thrips (Thysanoptera, Thripidae) in Australia, New Caledonia and New Zealand, Zootaxa. 1020: 1-64.

Mound, L., Nakahara, S and Tsuda, D.M. 2016. Thysanoptera-Terebrantia of the Hawaiian Islands: an identification manual. Zookeys, 549: 71-126.

Murai, T., Watanabe, H., Toriumi, W., Adati, T and Okajima, S. 2009. Damage to vegetable crops by *Thrips parvispinus* Karny (Thysanoptera: Thripidae) and preliminary studies on biology and control. Journal of Insect Science. 10: 166.

Murai, T., Watanabe, H., Wataru, T., Adati, T and Okajima, S. 2010. Damage to vegetable crops by *Thrips parvispinus* Karny (Thysanoptera: Thripidae) and preliminary studies on biology and control. In: Persley D, Wilson C, Thomas J, Sharman M, Tree D. (eds). IXth International Symposium on Thysanoptera and Tospoviruses, 31 August- 4 September, 2009. Journal of Insect Science. 10:166 available online: insectscience.org/10.166.

Nagaraju, D.K., Uppar, V., Ranjith, M., Sriharsha, Ramesh, G., Verma, O.M and Prakash, R. 2021. Occurrence of *Thrips parvispinus* (Karny) (Thripidae: Thysanoptera) in major chilli (*Capsicum annum*) growing areas of Karnataka. Insect Environment. 24(4): 523-532.

NPPO, 2019. *Thrips parvispinus*. Quick scan, QS.Ent./ 2019/001

Palmer, J.M. 1992. Thrips (Thysanoptera) from Pakistan to the Pacific: a review. Bulletin of the British Museum Natural History (Entomology). 61(1): 1-76.

Prabaningrum, L., Moekasan, T.K., Udiarto, B.K., den Belder, E and Elings, A. 2008. Integrated Pest Management on Sweet pepper in Indonesia: Biological control and control thresholds for thrips. Acta Horticulturae (ISHS). 767: 201-210, http://www.actahort.org/books/767/767_20.htm

Quick scan of *T. parvispinus :* file:///C:/Users/asf/Downloads/quickscan-thrips-parvispinus-october-2019%20(5).pdf

Rachana R.R., Roselin P., Amutha M., Sireesha K and Narasa Reddy G. 2021. Invasive pest, *Thrips parvispinus* (Karny) (Thysanoptera: Thripidae) – A looming threat to Indian agriculture. Current Science (In Press).

Rachana, R.R., Roselin, P and R. Varatharajan. 2018. Report of invasive thrips species, *Thrips parvispinus* (Karny) (Thripidae: Thysanoptera) on *Dahlia rosea* (Asteraceae) in Karnataka, Pest Management in Horticultural Ecosystems, 24(2): 175-176.

Rachana, R.R and Varatharajan, R. 2017. Checklist of terebrantian thrips (Insecta: Thysanoptera) recorded from India. Journal of Threatened Taxa, 9(1): 9748-9755.

Reyes, C.P. 1994. Thysanoptera (Hexapoda) of the Philipine Islands. The Raffles Bulletin of Zoology. 42: 1-507.

Riley, D.G., Joseph, S.V., Srinivasan, R and Diffie, S. 2011. Thrips vectors of tospoviruses. Journal of Insect Pest Management. 1: 1-10.

Sartiami, D., Magdalena and Nurmansyah, D.A. 2011. *Thrips parvispinus* Karny (Thysanoptera: Thripidae) pada Tanaman Cabai: Perbedaan Karakter Morfologi pada Tiga Ketinggian Tempat. J. Entomol. Indon. 8(2): 85-95.

Sartiami, D and Mound, L.A. 2013. Identification of the terebrantian thrips (Insecta, Thysanoptera) associated with cultivated plants in Java, Indonesia. ZooKeys.306: 1-21. doi: 10.3897/zookeys.306.5455.

Seki, M and Murai, T. 2012. Responses of five adult thrips species (Thysanoptera; Thripidae) to high-carbon dioxide atmospheres at different temperatures. Applied Entomology and Zoology. 47(2): 125-128.

Sireesha, K., B.V.L. Prasanna, T. Vijaya Lakshmi and Reddy, R.V.S.K. 2021. Outbreak of invasive thrips species *Thrips parvispinus* in chilli growing areas of Andhra Pradesh. Insect Environment. 24(4): 514-519.

Sridhar, V., R.R. Rachana, N.R. Prasanna, Kumar., Venkataramanappa., K. Sireesha., A. Anitha Kumari., K. Madhavi Reddy and M. Krishna Reddy. 2021. Displacement of *Scirtothrips dorsalis* by invasive *Thrips parvispinus* on chilli in southern states of India, Fifth National Symposium on Plant Protection in Horticulture, 27-29th December 2021.

Sugano J, Hamasaki R, Villalobos E, Sugano, J., Hamasaki, R, Villalobos, E., Chou, M.Y., Wright, M., Fukuda, S., Swift, S., Ferreira, S., Tsuda, D., Diaz-Lyke, M.D.C and Nakamoto, S.T. 2013. Pannakadadael dagiti papaya babaen kadagiti *Thrips parvispinus* (Karny). Honolulu (HI): University of Hawaii. 1 p.

Tyagi, K., Kumar, V., Singha, D and Chakraborty, R. 2015. Morphological and DNA barcoding evidence for invasive pest thrips, *Thrips parvispinus* (Thripidae: Thysanoptera), newly recorded from India. Journal of Insect Science, 15(1): 105.

Varatharajan, R., Shyam Maisnam, Chochong, Shimray V and Rachana, R.R. 2016. Pollination potential of Thrips (Insecta: Thysanoptera) - an overview. Zoo's print, XXXI (4): 6-12.

Zhang, H.R., Xie, Y.H., Li and ZY. 2011. Identification key to species of Thrips genus from China (Thysanoptera, Thripidae), with seven new records. Zootaxa 2810: 37-46, DOI: 10.5281/zenodo.277122