Monitoring, Diagnosis and Management of South East Asian Thrips, *Thrips parvispinus* in Chilli

सत्यमेव जयते

Government of India
Ministry of Agriculture & Farmer's Welfare
Department of Agriculture Cooperation & Farmer's Welfare
Integrated Pest Management Division
Directorate of Plant Protection Quarantine & Storage
Welfare, NH-IV, Faridabad
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आज़ादी का अमृत महोत्सव

FOREWORD

Chilli, which belongs to the family Solanaceae, is one of the most valuable commercial crops grown in India. It is majorly grown in the states of Andhra Pradesh, Telangana, Karnataka, Tamil Nadu and Maharashtra. Chilli is, in fact, the single largest spice exported from India.

Recently a new invasive thrips species *Thrips parvispinus* (Karny) infestation caused significant damage to the Chilli crops in southern states of India viz Andhra Pradesh, Telangana& Karnataka. Since *Thrips parvispinus* is an invasive pest species, it might have dominated/replaced the native chilli thrips, *Scirtothrips dorsalis* through competition. Various factors resulted in its sudden upsurge in chili ecosystem.

Concerted efforts have been made by Government of India for thrips management. This includes pest survey and monitoring at the district level, research by ICAR and awareness programs. Further, Integrated Pest Management (IPM) strategies are being promoted for pest control. IPM approach advocates utilization of alternate pest management techniques like cultural, mechanical and biological prior to use of chemical pesticides.

However, IPM strategy has currently shifted to more ecologically sustainable Agro-Eco System Analysis (AESA) based decision making aimed at selection of appropriate IPM techniques. Considering this, the Directorate of Plant Protection Quarantine and Storage (DPPQS) has published (AESA) based IPM package of practices for Chilli/ Capsicum for awareness of farmers and researchers.

This booklet provides the necessary information that would help farmers and other stakeholders in timely and effective management of the pest. This would in turn boost the production and hence the exports and farmers' income. I hope this booklet proves to be a handy and useful document for Central and State government functionaries involved in extension and farmers.

I take this opportunity to congratulate the resource personnel of DPPQS, ICAR & SAU in bringing out the booklet. But for their timely and sincere efforts , this booklet on "Monitoring, Diagnosis and Management of South East Asian Thrips, *Thrips parvispinus*", would not have seen the light of day.

Dr. Pramod Kumar Meherda
Joint Secretary (Plant Protection)

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FOREWORD

Scirtothrips dorsalis is the most important thrips species infesting Chilli crops in India. *Scirtothrips dorsalis* damage plant sucking sap from undersurface of the leaves and is the major problem of un-irrigated field during dry weather condition. Farmers adopt management practices for *Scirtothrips dorsalis* thrip species. DPPQS also published AESA based IPM package of practices for Chilli/ Capsicum which include management of *Scirtothrips dorsalis* thrip species.

Recent outbreak of new invasive thrips species *Thrips parvispinus* (Karny) in Southern India is mainly colonizing in reproductive parts i.e. flowers and causing huge damage. *Thrips parvispinus* infestation increased during heavy rainfall of North East monsoon in contrast to other thrips species. Farmers could not control this new species despite spray of several chemical pesticides.

The resource persons of DPPQ&S, ICAR & SAU have made sincere efforts in bringing out this booklet on "Monitoring, Diagnosis and Management of South East Asian Thrips, *Thrips parvispinus* in Chilli" by incorporating biology of pest, identification key, damage symptoms, integrated management strategies. I convey my sincere thanks to Dr. S.C. Dubey, ADG (PP), ICAR, New Delhi for reviewing this booklet.

I hope this booklet will serve as a ready reference for extension functionaries of Central / State Governments, NGOs and farmers for management of *Thrips parvispinus* in chilli.

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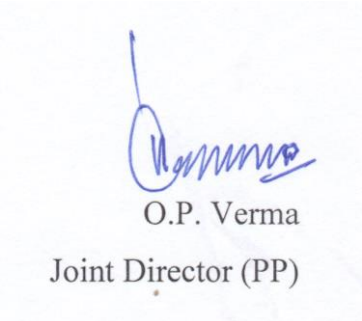
PREFACE

India is the world largest producer of chilli accounting around 36% of world production. It is an essential spices of Indian culinary used fresh green form and in dried form. Pest & disease infestation and infection is effectively managed by farmers by adopting Integrated Pest Management techniques. However, farmers from Andhra Pradesh, Telangana & Karnataka suffered huge crop loss due to new invasive thrips species *Thrips parvispinus* and necessitated development of management strategies immediately.

I convey my sincere thanks to Joint Secretary (Plant Protection) & Plant Protection Adviser for encouragement and facilities for compilation of this booklet and also to ADG (PP), ICAR, New Delhi for reviewing.

This booklet on "Monitoring, Diagnosis and Management of South East Asian Thrips, *Thrips parvispinus* in Chilli" will prove an important guide for extension functionaries of Central / State Governments, NGOs and farmers for management of *Thrips parvispinus* in Chilli.



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CONTENT

Monitoring, Diagnosis and Management of South East Asian Thrips, *Thrips parvispinus* in Chill

1. Introduction

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. Recently an outbreak of *Thrips parvispinus* (Karny) (Thysanoptera: Thripidae) has been reported from southern states (Andhra Pradesh, Karnataka and Telangana) especially on chilli crops causing 50-80 per cent damage.

The genus *Thrips* is one of the largest genera of the insect order Thysanoptera in the family Thripidae, with 301 species worldwide (ThripsWiki 2022), 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 rasping and sucking the sap from different parts of the plant with 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).

About *Thrips parvispinus*

Thrips 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. *Thrips 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 species in India has been first reported by Tyagi*etal*., (2015) on papaya from Bengaluru.

Common name (s)
Tobacco thrips, Taiwanese thrips and South East Asian Thrips

2. Nature and Symptoms of Damage:

Thrips parvispinus adults colonize mainly on flowers and underside of leaves while larvae restrict themselves to under surface of the leaves. Both adults and larvae damage plants by rasping and sucking of the plant sap. Heavy infestation affects the growth of the plant, flower drop and reduces fruit set and development, ultimately resulting in yield loss. During 2021, heavy infestation due to *T. parvispinus* was observed due to heavy rainfall of North East monsoon in contrast to other thrips species in southern parts of the country in chilli crop.

The symptoms due to thrips damage include deep punctures and scratches on underside of the leaves. Infested undersurface of the leaf turns reddish brown, whereas upper side of such leaf looks yellowish. Distorted leaf lamina with necrotic areas and yellow streaking are quite common symptoms. On floral parts, brownish streaks appear on petals due to scraping by thrips. The damage results in drying and withering of flowers leading to reduced fruit set. Severe infestation affects the growth of the plant as thrips feed on growing portions of the plant and flower drop is also observed in the severely infested fields. Several adults, both males and females were observed feeding and hiding in the nectariferous area of chilli flowers.

Scirtothrips dorsalis **damage symptoms**

Thrips parvispinus damage **symptoms**

On leaves

1. Thrips prefer areas adjacent to veins for colonizing and feeding.
2. Deep punctures and scratches on the underside of the leaves.
3. Due to scrapping of chlorophyll on underside of leaves and sucking of cell sap corresponding portion on upper side of leaves appears yellowish and blotchy

4. Reddish brown discolouration on under the surface of the leaves.
5. Distorted leaf lamina with necrotic areas and yellow streaks.
6. New flesh completely dry or blighted in case of sever infestation.

On floral parts

1. Brownish streaks on the petals due to scraping by thrips.
2. Pollination may be affected due to feeding on pollen.
3. Drying and withering of the flower.
4. Affect fruit set.

Adults of *T. parvispinus* feeding on chilli flowers (Black and large females; yellow and small males)

3. Identification of thrips species damaging chilli

A total of six species of thrips have been reported on chilli in India. These species are *Frankliniella schultzei* (Trybom), *Scirtothrips dorsalis* Hood, *Thrips florum* Schmutz, *Thrips hawaiiensis* (Morgan), *Thrips palmi* Karny and *Thrips parvispinus* (Karny). *Scirtothrips dorsalis* is the common chilli thrips. However, the invasion of alien pest, *Thrips parvispinus* during 2021-22 onwards has predominated species over *S. dorsalis* in chilli ecosystem.

Diagnosis of thrips species

***Frankliniella schultzei* (Trybom)**

Female: Body yellow with or without brown shading on tergites, antennal segments VI–VIII brown; forewing transparent. Antennae 8 segmented; III–IV with a forked sense cone. Head with ocellar setae 3 pairs, pair III arising closely between anterior margins of posterior ocelli

and almost as long as side of ocellar triangle; postocular setae pair IV as long as distance between posterior ocelli. Pronotum having 5 pairs of major setae; anteromarginal setae shorter than anteroangulars, a pair of minor setae present medially between posteromarginal submedian setae. Metanotum with median setae at anterior margin without campaniform sensilla. Forewing first and second veins with complete rows of setae. Abdominal tergites VI –VIII with paired ctenidia, on VIII anterolateral of spiracle; posteromarginal comb on VIII absent. Abdominal sternites III–VII without discal setae (Fig A).

Male: Similar to female in colour and sculpture but smaller; abdominal sternites III-VII with broadly transverse pore plate.

***Scirtothrips dorsalis* Hood**

Female: Body yellow with median brown marking on abdominal tergites III–VII, abdominal sternites without brown markings but with brown antecostal ridges on tergites and sternites; forewing shaded but with paler apex; antennal segment I whitish, II shaded, III–VIII dark. Head with closely striate postocular and ocellar regions; ocellar setae pair III arise between posterior ocelli, well behind tangent between their anterior margins; 2 pairs of post-ocellar setae as long as ocellar setae pair III. Pronotum striate closely, posteromarginal setae S2 longer than S1. Metanotal sculpture variable, generally transversely arcuate anteriorly, with irregular longitudinal reticulations or striations posteriorly; median pair of setae behind anterior margin. Forewing second vein with 2 setae. Abdominal tergites III–V with bases of median setae closer together than length of these setae; tergalmicrotrichial fields with 3 discal setae; VIII with discalmicrotrichia present anteromedially, posteromarginal comb complete; IX with discalmicrotrichia present posteromedially. Abdominal sternites with microtrichia extending across median area on posterior half. (Fig.B)

Male: Similar to female in colour and sculpture, but smaller in size.(Fig.C)

***Thrips florum* Schmutz**

Female: Body brown, tibiae yellow, femora pale brown; antennal segment III yellow; forewing brown with paler base. Antennae 7 segmented. Head with ocellar setae III outside ocellar triangle; postocular setae II very much smaller than I or III. Mesonotum without sculpture lines close to anterior campaniform sensilla. Metanotum transversely striate on anterior half, with longitudinal more widely spaced striations on posterior half; median setae arise at anterior margin; campaniform sensilla present. Forewing first vein with 3 distal setae,

clavus with subapical seta longer than apical seta. Abdominal tergite II with 4 lateral marginal setae; comb on VIII complete but short and irregular. Abdominal sternites III–VII with 6–14 discal setae. (Fig F)

Male: Smaller than female. Body yellowish brown. Abdominal tergite IX with 4 evenly spaced setae, median pair longer and stouter. Abdominal sternites III-VII with transverse pore glands.(Fig.G)

***Thrips hawaiiensis* (Morgan)**

Female: Body brown or bicoloured with abdomen brown and head and thorax yellowish orange; antennal segment III yellow; forewing brown with paler base. Antennae 7 segmented. Head with ocellar setae III outside ocellar triangle; postocular setae I and II subequal. Mesonotum with sculpture lines close to anterior campaniform sensilla. Metanotum anteriorly transversely striate, posteriorly with longitudinal but more widely spaced striations; median setae arise at anterior margin; campaniform sensilla present. Forewing first vein with 3 distal setae; clavus with apical seta longer than subapical seta. Abdominal tergite II with 4 lateral setae; VIII comb complete but short and irregular; pleura tergites without discal setae. Abdominal sternites III–VII with 12–25 discal setae.(Fig.D)

Male: Similar to female but smaller. Body yellowish brown. Abdominal tergite IX with 4 setae, almost equal in length, distance between median pair longer than the distance between median and submedian pair. Abdominal sternites III–VII with transverse glandular areas.(Fig.E)

***Thrips palmi* Karny**

Female: Body and legs yellow; antennal segments IV and V brown apically, VI and VII brown; forewing pale. Head with small ocellar setae pair III, arising outside ocellar triangle; postocular setae pair I slightly longer than ocellar setae III. Antennae 7 segmented. Pronotum with 2 pairs of very long posteroangular setae, 3 pairs of posteromarginal setae. Metanotum with irregular longitudinal lines converging to posterior margin, with anteriorly curving transverse lines; median setae arising well behind anterior margin, campaniform sensilla present. Forewing first vein with 3 distal setae, second vein with 11–15 setae. Abdominal tergite II with 4 marginal setae laterally; VIII with complete comb; discal setae on pleura tergites absent. Abdominal sternite VII with median setae pair arising in front of margin; discal setae on sternites absent. (Fig. H)

Male: Smaller than female; abdominal sternites III–VII with transverse glandular area. (Fig.I)

***Thrips parvispinus* (Karny)**

Female: Body brown, head and thorax lighter than abdomen; legs yellow; antennal segment III and basal half of IV and V yellow; forewing brown with pale base. Head wider than long, ocellar setae pair III small and positioned on anterior margins of ocellar triangle; postocular setae pairs I and III marginally longer than ocellar setae pair III, pair II minute. Antennae 7 segmented, III and IV constricted at apex with a forked sense cone, VII small. Pronotum with 2 long posteroangular setae pairs; 3 pairs of posteromarginal setae. Metanotum with median reticulations; with weak internal markings; median setae long and placed behind anterior margin; without campaniform sensilla. Forewing first and second veins with complete setae rows; clavus with 5 marginal setae. Abdominal tergite II with 3 lateral marginal setae; VIII without posteromarginal comb, a few microtrichia laterally present; pleura tergites without discal setae. Abdominal sternite II with 2 marginal setae pairs, III–VII with 3 pairs, VII with 23 median setae pair arising in front of posterior margin; II and VII without discal setae, III–VI with about 6–12 discal setae arranged in an irregular row.(Fig.J)

Male: Smaller to female; yellow.

Key to the genera of thrips recorded on Chilli

1. Antennae 7 segmented…….....……....***Thrips***

- Antennae 8 segmented……..…….....…….....**2**

2. Abdominal tergites with lateral thirds completely covered with numerous microtrichia…….....***Scirtothrips***

- Abdominal tergites without lateral thirds completely covered with numerous microtrichia…….....…….....***Frankliniella***

Key to the species of thrips recorded on Chilli

1. Antennae 8 segmented…….....……...**2**

- Antennae 7 segmented…….....……...……**3**

2. Abdominal tergites with lateral thirds completely covered with numerous microtrichia…….....….……***Scirtothrips dorsalis***

- Abdominal tergites without lateral thirds completely covered with numerous microtrichia……...……***Frankliniella schultzei***

3. Abdominal sternites without discal setae…….....***Thrips palmi***

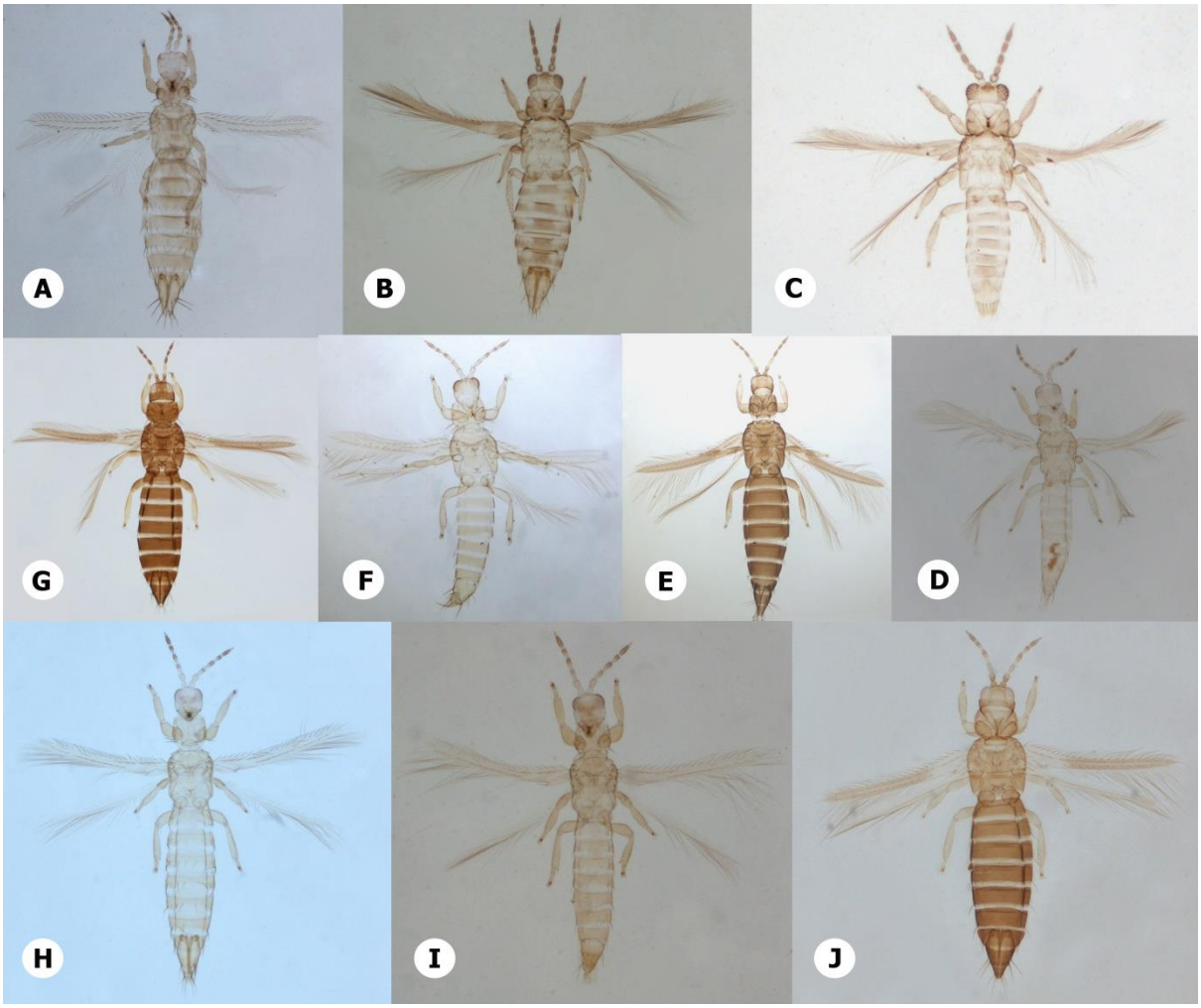
- Abdominal sternites with discal setae…….....**4**

4. Abdominal sternite VII without discal setae…….....***Thrips parvispinus***

- Abdominal sternite VII with discal setae……..…….....**5**

5. Mesonotum sculptured around campaniform sensilla near anterior margin; clavus with apical seta longer than subapical seta.....***Thrips hawaiiensis***

- Mesonotum not sculptured around campaniform sensilla near anterior margin; forewing clavus with apical seta shorter than subapical seta.....***Thrips florum***



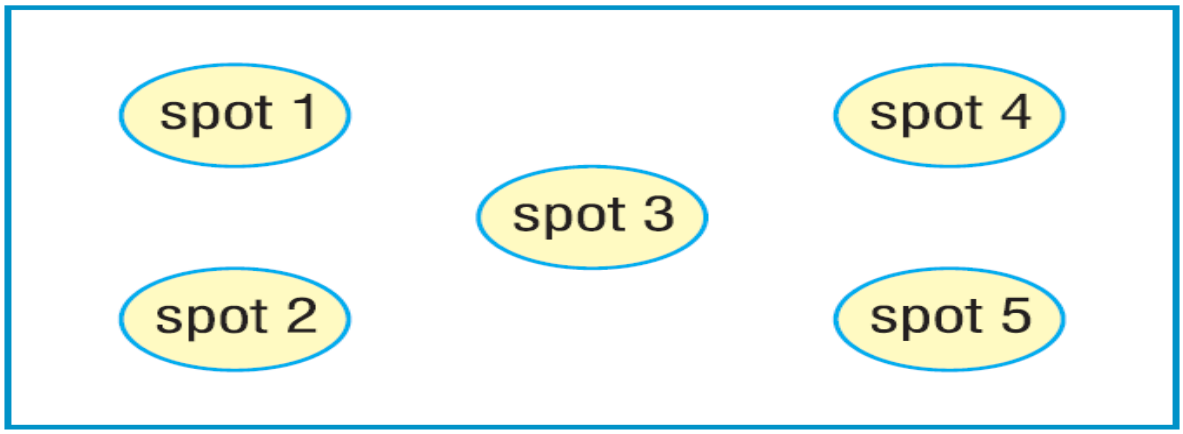
Figures A-J: Thrips species. A, Female *Frankliniella schultzei*; B, Female *Scirtothrips dorsalis*; C, Male *Scirtothrips dorsalis*; D, Male *Thrips hawaiiensis*; E, Female *Thrips hawaiiensis*; F, Male *Thrips florum*; G, Female *Thrips florum*; H, Female *Thrips palmi*; I, Male *Thrips palmi*; J, Female *Thrips parvispinus*

4. Pest Surveillance and Monitoring

4.1 Roving Survey: Roving Survey is suggested for assessing pest population/ damage wherein pest information is gathered from randomly selected spots over large area in a short period. The survey routes need to be finalized before the commencement of the seasons. The survey route should be determined in such a way that it is as circular as possible to cover maximum area or districts. If survey of all the districts is not possible then the number of survey teams will have to be increased, so that survey of all the affected areas can be done in 7-10 days interval. The survey routes should cover major crops grown in the state. The survey team should be finalized before onset of surveillance programmes. The time interval between surveys should be at least a minimum of 7 to 10days. The survey should spread over in the entire crop season. The survey report once finalized maysent to headquarters and to concerned district heads of state departments through fastest mode. Wherever forewarning is required to be issued, it should be done on the same day during survey period. A minimum of 100-150 kmmay be covered in a day. Observations needs to be recorded at least at every 5 km distance covering both sides of the road.

Sampling within the field

In each of the fields, five spots needs to be selected randomly as shown (four in the corners, at least 5 feet inside of the field borders, and one in the centre). In each spot, five random plants may be selected for recording population of insects as per procedure.



Survey report

1.**(A.) BASIC INFORMATION**

Sl. No.	**Team Members**	
	Survey dates	
	District Covered	
	Survey routes*	Day 1: Day 2: ……..
	Nos. of Fields Observed & area covered (ha.)	

(B) Pest & Disease situation- Sheet enclosed ()
(D) Technical Remark on pest's situation, crop condition, weather condition *etc*:

(E) Farmers practices for pest management:

(F) Forewarning/ advisory to be issued:

Signature of survey team members

(B) **PEST & DISEASE SITUATION-**

Sl no.	**Dist.**	***Block***	**Village**	**Longitude**	**Latitude**	**Weather**	**Crop**	**Stage**	**Area (ha.)**	**Name of pests/ disease /weeds**	**Intensity**	**Name of natural enemies**	**Intensity**

Important photographs of infestation to be enclosed with proper caption

4.2Monitoring methods for thrips

The regular monitoring of the population size of thrips at different crop stage is crucial in the effective management. Through monitoring, presence or absence of the pest, and abundance of the pest on crop is known there by pesticide usage can be minimized. Current recommendation for monitoring thrips is(i) Use of blue and yellow sticky traps and (ii) Collection of plant samples and visual counts of thrips in the field.

4.2.1. Monitoring thrips by sticky traps:

The sticky traps are employed for monitoring the presence, abundance, seasonal changes and behaviour of thrips(Takagi 1978, Puche et al. 1995, Lewis 1997b, Grove et al. 2000, Pearsall and Myers 2001, Casey and Parrella 2002, and Nault et al. 2003). Monitoring thrips by coloured sticky traps are found to be the most simple, low-cost and an effective tool. The

presence of thrips and their numbers and mass trapping of the thrips can be achieved by using these traps. Sticky traps capture thrips more readily and continuously with reduced human efforts. Though both yellow and blue sticky traps attract various thrips species, preliminary studies indicated that more number of *T. parvispinus* attracted to blue sticky traps than yellow sticky traps (Sireesha et al., 2021).Hence, blue sticky traps can be employed for monitoring the *T. parvispinus* population in the open field conditions. In chilli nursery, traps are to be installed at the ground level near to the seedlings, while in the main field trap should be installed at the crop canopy level. Uniform distribution of 20-25 traps/ha. throughout the field is necessary for monitoring purpose, whereas 65-75/ha. Blue sticky traps are to be placed in the transplanted crop for mass trapping. The traps are replaced at weekly intervals with new ones depending on the pest load.

Specification of traps

- Colour of the trap: Blue
- Size of the trap:15x20 cm or 30x20 cm

Advantage of the method

- It is the simplest method to monitor the thrips at field level by the farmer

4.2.2 Monitoring the thrips density by collection and washing of plant samples
(Absolute counts)

This technique is useful for monitoring the population density of thrips species inhabiting the crop and provides the absolute estimates of the population of both larval and adult stages of the thrips inhabiting the young leaf terminals and flowers. The leaves are collected in the morning hours starting from 20 days after sowing of nursery till the harvesting of the crop for monitoring of thrips on leaves. Whereas, flowers are collected from the date of flowering till the harvest of the crop at weekly intervals. Twenty-five young terminal leaves and 50 flowers are randomly collected from the field from five different spots and placed in plastic grip bag containing 70% ethyl alcohol solution.The bags containing the plant samples are agitated continuously for few minutes and filtered through filter paper and observed under microscope. The thrips present on the fruits are collected gently by placing 10 fruits randomly collected from the field from five different spots in to a zip lock polythene cover and the thrips present on the fruits are processed in the laboratory.

Procedure:

- Randomly select five spots in a field
- From each spot collect 5 terminal shoots, 10 flowers and 10 fruits in separate zip-lock covers.
- Place them individually and wash with 40 % ethyl alcohol
- Filter through whatman filter paper
- Count the number of thrips using magnifying lens or under microscope.
- Preserve thrips thus collected in 70% ethyl alcohol for further identification.

Advantage of the method:

- More accurate, reliable and simple
- Useful for scientific study and specimens can be retrieved without damaging body parts

4.2.3. Visual counts of thrips by tapping plant parts on plastic trays

One of the easiest and simple method to collect thrips is to beat the plant together with leaves, branches, flowers and fruits on a small white/black plastic tray (Powell and Landis, 1965). Thrips thus fell on the plastic tray are counted and collected using a camel hair brush and preserved in 70% ethyl alcohol for further studies. This method of monitoring is highly useful for the extension workers to assess the population counts of thrips in the field itself.This method provides information on the population fluctuation across the seasons (Aliabarpour and Rawi, 2010, Oroszet al., 2017). Care should be taken to select uniform sized shoots, flowers and fruits at each spot to get the unbiased count on population.

Procedure

- Randomly select five spots in the field
- From each spot tap uniform sized five shoots together with twigs, flowers and fruits
- Count number of thrips fallen on the white sheet/tray

Advantage of the method

- Easiest and simple method
- Useful for extension workers and others during survey

5. Good Agricultural Practices for the management of *T. parvispinus*

Though the chilli crop is cultivated on large scale on all types of soils and under varied climatic conditions, certain practices are very important to curtail the development of pests and diseases and to get the good quality crop with less input cost.

5.1 Climate and soils

- Well drained black soils and light soils with good irrigation facilities are better suited for chilli cultivation. Crop grown under ill drained conditions suffers more from attack of pests and diseases.
- Adequate moisture needs to be maintained for the crop in order to maintain the turgidity in the plant cells.

5.2 Selection of variety

- Selection of Resistant or tolerant varieties is the first step to be followed to reduce the damage due to the pest as evident in case of *T.parvispinus* infestation.

5.3 Nursery management

- Selection of healthy seedlings is very important to get good yield.
- Seed treatment with Imidacloprid 70 WS @10 g per kg seed prevents the sucking pest infestation.
- Raise seedlings in protrays under polyhouse condition with insect proof nets. Under open field conditions preference should be given for raised nursery beds and care should be taken to prevent the sucking pest infestation at nursery stage by monitoring the sucking pests with sticky traps.
- Five to six weeks old healthy seedlings are good for transplanting in the main field.

5.4 Manures and fertilizers

- Application of recommended dose (25-30 t/ha) of Farm Yard Manure (FYM), vermicompost and neem cake as basal dose as mentioned in IPM practices furnished below.
- Application of synthetic fertilizers as recommended by respective State Agricultural or Horticultural universities or Departments.
- Application of Phosphorus fertilizers (doses) as basal dose only.

- Use of straight fertilizers is recommended and avoid complex fertilizers which may lead to nutrient imbalance.
- Micronutrient deficiencies may be addressed by spraying foliar nutrients
- Avoid application of excess nitrogenous fertilizers as it makes plants more succulent and attractive, thereby plants are prone to severe pest attack

5.5 Inter cultural operations and weed management

- Inter-cultivation with tyned harrow or blade harrow at 15 to 20 days interval to suppress weed growth and it is best suited to disturb the life cycle of *T.parvispinus* as it pupates in the soil.
- Fields and bunds should be maintained weed free.
- Raking of the soil at the time of removing weeds helps in destroying pupae.

5.6 Irrigation

- Number and frequency of irrigation depends on soil type, age of crop and climate
- Irrigation at 40-60% depletion of available soil moisture is suggested to maintain good crop growth.
- Supplemental irrigations need to be provided to save the crop during severe drought particularly at critical stages of crop growth.

5.7 Flower drop

- Flower drop in chilli is influenced by the climatic conditions and moisture level in the soil. Severe pest infestation such as thrips can also cause flower drop.
- Spray NAA 10ppm 2 to 3 times at 20 days interval (1 ml per 9 L of water) during the cooler parts of the day.

5.8 Integrated pest and disease management

- Follow integrated management for management of pests& diseases.

6. Integrated Pest Management (IPM) approaches for *T. parvispinus*

The following IPM practices are suggested for management of thrips complex on chilli. The IPM practices have to be followed under wide area basis/community approach for better results.

6.1 Cultural Methods

a) Deep summer ploughing to destroy pupae and residual stages of thrips and other pests.
b) Advance cropping season and avoid staggered planting.
c) Application of well decomposed farm yard manure (FYM) or compost @ 2.5 t/ha, enriched with *Metarhizium anisopliae* or *Pseudomonas fluorescens* @ 2 kg/t along with recommended doses of farm yard manure (25 to 30t/ha).
d) Soil application of 500 kg of Neem cake and 1.50 -2.00t on of vermi-compost/ha to induce resistance against thrips
e) Growing resistant or early/short duration varieties if available in order to escape the peak incidence of thrips.
f) Seed treatment with Imidachlorpid 70WS @10 g per kg seed.
g) Seedling root dip for 30 minutes with Imidachlorpid 17.8% SL @ 0.5 ml/ L.
h) Follow recommended spacing (60 x 30 cm or 45 x 45 cm) and avoid close spacing, as the high density planting favors the pest incidence and multiplication.
i) Balanced fertilization with enhanced potash application along with nitrogen and phosphorous fertilizers to induce plant resistance against the pest.
j) Mulching with silver coloured polythene sheets of 25–30 micron thickness to reduce pupation of thrips in the soil.
k) Border cropping with 2-3 rows of tall growing crops like sorghum / maize / bajra / fodder grasses etc. sown thickly as a barrier for thrips movement.
l) Intercropping chilli with maize / sorghum and cowpea at10:3:1 as barrier and reservoir crops for natural enemy multiplication, leading to biological control of thrips.
m) Frequent inter cultivation (earthing up/raking of soil) operations to destroy soil inhabiting pupae of thrips
n) Clean cultivation and maintaining weed free bunds are crucial for the management of pests. Uprooting and destruction of weeds such as *Parthenium hysterophorus*, *Cleome*

viscosa, Prosopis sp., *Lantana camara, Calotropis* sp., *Tecoma* sp., *Abutilon* sp., wild *Solanum* sp., etc. present in the vicinity of field bunds which act as off season and alternate host for thrips.

o) Crop rotation with crops belonging to the family Poaceae or Gramineae (cereals).

6.2 Mechanical Methods

a) Nipping and destruction of severely infested apical shoots at vegetative stage for destruction of thrips residing over apical parts.
b) Mechanical destruction of severely infested plants by uprooting and burying or incineration.
c) Erection of blue or yellow/white sticky traps at65–75 traps/ha at crop canopy height for mass trapping purpose and 20-25 traps/ ha for monitoring purpose.
d) Adopting sprinkler irrigation system instead of flood irrigation, since the jet of water spray from sprinklers disrupts the growth and multiplication of thrips.

6.3 Biological Methods

a) Conservation of native natural enemies by avoiding spraying of chemical pesticides to the extent possible.
b) Spraying of microbial based insecticides like *Beauveria bassiana* or *Lecanicilium lecanii* at 4.00 g or ml/L (spore load - $1x10^8$cfu/g or ml), *Pseudomonas fluorescence* – NBAIRPFDWD at 20g/L or *Bacillus albus* – NBAIR-BATP @ 20 g/L uniformly covering whole plant.
c) Foliar spray of Entomo-Pathogenic Nematode (EPN), *Steinernema carpocapsae* formulation at10g/L + 1 g wetting agent.
d) Soil application of EPNs, *Steinernema carpocapsae*or *Heterorhabditis indica* at7.50-12.50 kg/ha. It can be applied as soil drenching after mixing in 500 -750 L of water. EPN's are to be used early in the morning or during late evening hours as they are sensitive to UV and high temperature. Spraying of EPNs in peak sunshine hours be avoided.

6.4 Botanical/ Organic Methods

a) Spraying % Neem Seed Kernel Extract (NSKE) or 5% Neem Seed Powder Extract or 0.50% Neem oil (5 ml/L), 0.50% Pongamia oil (5 ml/L), and 5% *Vitex negundo* extract (50 ml/L).

b) Spraying of commercial formulation of neem based insecticide (Azadirachtin3000 PPM) @ 2 ml/L.(how much water/ha)
c) Spraying of 2% Fish Oil Rosin Soap (FORS) (20 ml/L) solely or in combination with Neem Seed Kernel Extract
d) Spraying of sea weed (*Kappaphycus alvarezii*) extract @ 2 ml/L for inducing resistance in plant to withstand the severe incidence of thrips.

6.5 Chemical Methods

a) As a final resort, need based and judicious spray of label claim insecticides as given in Annexure below.
b) Sprayings should be taken up uniformly covering whole plant
c) The insecticide solutions to be added with appropriate stickers and spreaders while spraying.
d) Spraying of unregistered agro-chemicals such as pesticides, plant growth regulators, nutrient mixtures, *etc.* to be strictly avoided.
e) The waiting periods mentioned against insecticide molecules (furnished in the annexure below)to be followed to avoid pesticide residues in the harvested produce.
f) Repeated spraying of chemical insecticides with same mode of action and spraying of sub-lethal doses to be avoided to overcome thrips resurgence (sudden outbreak).

6.6 Legal control/ Export

It is observed that mature leaves and fruits harbor less number of thrips. Therefore, possibility of association of thrips on a fully mature green chilli fruits is remote. However, petiole region of the chilli has to be thoroughly inspected during routine Phytosanitary inspections of the export shipments. For the purpose of red chilli export, fully ripen and partially withered pods are harvested. Harvested pods are sun dried to bring down the moisture to 10%. The process of harvesting and sun drying eliminate all the insect pest, if they are associated. Therefore, *T. parvispinus* or any other species of thrips for that matter are not an impediment in export of red chilli. However, pesticide residues should be monitored by following waiting period.

Annexure: CIB & RC approved registered Insecticides for Thrips in Chilli

Insecticides	**Dosage per ha in required water**	**Waiting period (in days)**
Acephate 95 % SG	790 g in 500 L	07
Acetamiprid 20 % SP	50-100 g in 500-600 L	03
Carbofuran 03 % CG	33.30 kg	--
Cyantraniliprole 10.26% OD	600 g in 500 L	03
Dimethoate 30 % EC	600 ml in 500-1000 L	--
Emamectin benzoate 05% SG	200 g in 500 L	03
Emamectinbenzoate1.90%EC	375 ml in 500 L	14
Ethion 50 % EC	1.50-2.00 L in 500-1000 L	05
Fenpropathrin 30 % EC	250-340 ml in 750-1000 L	07
Fipronil 05 % SC	800-1000 g in 500 L	07
Fipronil 80 % WG	50.00 -62.50 g in 500 L	5
Imidacloprid 70 % WS	1.00 -1.50 kg	--
Imidacloprid30.50%m/m SC	125-150 g in 500 L	5
Imidacloprid 17.80 % SL	125-250 ml in 500-700 L	40
Lambdacyhalothrin4.90%CS	500ml in 500 L	5
Lambda-cyhalothrin05% EC	300 ml in 400-600 L	5
Methomyl 40 % SP	0.75-1.12 kg in 500-1000 L	5-6
Oxydemeton-methyl25% EC	1 L in 500-1000 L	--
Spinosad 45 % SC	160 g in 500 L	3
Spirotetramat15.31%w/wOD	400 g in 500 L	5
Thiacloprid 21.70% SC	225-300 g in 500 L	5
Thiamethoxam 30 % FS	Used as seed dresser	
Tolfenpyrad 15 % EC	1 L in 500 L	7
Diafenthiuron 47 % + Bifenthrin 09.40 % w/w SC	625 ml in 500 L	7
Emamectin Benzoate 01.50 % + Fipronil 03.50 % SC	500-750 g in 500 L	3
Emamectin benzoate5 % w/w + Lufenuron 40 % w/w WG	60 g in 500 L	3
Flubendiamide 19.92 % + Thiacloprid	200-250 ml in 500 L	5

19.92 % w/w SC		
Fipronil 07 % + Hexythiazox 02 % w/w SC	1 L in 500 L	7
Hexythiazox 3.5% + Diafenthiuron 42% WDG	650 g in 500 L	7
Indoxacarb 14.5 % + Acetamiprid 7.7 % w/w SC	825-875 ml in 500 L	5
Profenofos 40 % + Fenpyroximate 2.5 % w/w EC	1 Lin 500 L	7

7. Agro ecosystem analysis (AESA) based decision making for pest management

Decision making in pest management requires a thorough analysis of the agro- ecosystem. Farmer has to learn how to observe the crop, how to analyze the field situation and how to make proper decisions for their crop management.

7.1 The basic components of AESA are

- Plant health at different stages
- Built-in compensation abilities of plants
- Pest and defender population dynamics
- Soil conditions
- Climatic factors
- Farmers past experience

7.2 Principles of AESA based IPM

- Grow a healthy crop
- Observe the field regularly (climatic factors, soil and biotic factors)
- Plant compensation ability
- Understand and conserve defenders

Farmers have to make timely decisions about the management of their crops. AESA farmers have to learn to make these decisions based on observations and analysis viz. abiotic and biotic factors of the crop ecosystem. The past experience of the farmers should also be considered for decision making. However, as field conditions continue to change and new

technologies become available, farmers need to continue improving their skills and knowledge.

9. Do's and Don'ts in chilli cultivation

Do's	Dont's
1. Follow crop rotation with non-host crops such as cereals, millets and vegetables like cruciferous crops sweet corn etc. 2. Raised bed system with assured drainage coupled with drip irrigation and mulching should be followed. 3. Grow 2-3 rows of border crop with maize/sorghum/ bajra. 4. Raise best quality nursery on raised bed/protray under insect proof net. 5. Use good quality reflective mulch of 25-30 microns keeping black colour surface facing downside. 6. Treat the seeds with insecticides and fungicides to withstand insect and diseases in the early stage of the crop 7. Follow proper planting timings recommended by ICAR institutes/ SAUs/ KVKs. 8. Follow recommended spacing as per the cultivar growth pattern. 9. Wherever raised bed and mulching method is not followed, light hoeing should be done in initial stage after transplanting to keep the field weed free and to conserve soil moisture. 10. Use insect sticky traps (yellow/blue) 11. For dry chilli cultivation, Sulphate of potash (SOP) should be preferred in place of Muriate of potash (MOP). 12. Apply entire recommended quantity of phosphorus as basal dose and avoid split and excess doses of P fertilizers. Only recommended dose of fertilizers should be applied. 13. Keep the field free from weeds and fallen fruits or foliage to minimize disease and insect issues. 14. Rotate Spinosad with biological control fungi, *Metarhizium brunneum* and *Beauveria*	1. Avoid high nitrogen and phosphorus usage. 2. Avoid use of plant growth regulators of unknown composition. 3. Avoid insecticide/ chemicals sprays before picking. 4. Avoid spray of chemicals with same mode of action. 5. Avoid calendar based pesticide spray. 6. Avoid mixing of pesticide formulations 7. Spraying of unregistered agro-chemicals such as pesticides, plant growth regulators, nutrient mixtures, *etc*. to be strictly avoided. 8. Avoid excessive use of pesticides

bassiana or insect growth regulator (azadirachtin etc.), and plant oils like neem or pongamia. 15. Harvest matured green/ red fruits in rain free day. 16. Follow proper drying method (solar drying or poly tunnel drying) **17.** Follow recommended waiting periods for harvest after spraying pesticides.	

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