A REVIEW ON THE INVASIVE ALIEN SPECIES, *Thrips parvispinus* (KARNY) – BIOECOLOGY, HOST RANGE AND MANAGEMENT

JEYASHREE J [a] AND ARIVUDAINAMBI S [b]

[a] Department of Agricultural Entomology, Uttar Banga Krishi Vishwavidyalaya, Pundibari, West Bengal – 736165.

[b] Department of Entomology, Annamalai University, Chidambaram - 608002, Tamil Nadu, India.

*Email: jeyashreejeyaselvan@gmail.com (corresponding author)

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ABSTRACT

Invasive alien species (IAS) are among the leading drivers of biodiversity loss, severely impacting agricultural ecosystems. *Thrips parvispinus* (Karny), commonly known as the Tobacco black thrips, has emerged as a major pest, affecting a wide range of agricultural and horticultural crops globally. Native to Southeast Asia, *T. parvispinus* has rapidly expanded its distribution due to globalization, climate change, and international trade. This pest is characterized by its high reproductive rate, adaptability to diverse environmental conditions, and ability to displace native thrips species, resulting in extensive crop damage. *T. parvispinus* has been recorded in various regions, including Southeast Asia, Australia, Greece, and multiple Indian states, where it has significantly impacted chilli, papaya, and other economically important crops. The species undergoes a complex life cycle, with five immature stages, and exhibits a strong preference for flowers and leaves, causing severe plant damage. Population dynamics are influenced by factors such as host plant abundance, temperature, and light intensity. Moreover, *T. parvispinus* has been identified as a vector of plant viruses, further exacerbating its impact on agricultural production. This review consolidates existing knowledge on the bioecology, global distribution, host range, and population dynamics of *T. parvispinus*. It also explores sustainable management strategies to mitigate its effects on agriculture. Understanding its invasiveness is crucial for developing integrated pest management approaches to minimize economic losses and ensure sustainable crop production.

INTRODUCTION

Invasive alien species (IAS) are among the leading causes of biodiversity loss, posing significant ecological and economic threats to agricultural ecosystems worldwide. These species often thrive in non-native environments due to their adaptability, rapid reproduction, and lack of natural enemies (European Commission, n.d.). Among them, invasive insect pests have drawn considerable attention for their potential to disrupt crop production. One such pest is *Thrips parvispinus* (Karny), commonly known as the Tobacco black thrips. Native to Southeast Asia, *T. parvispinus* has emerged as a formidable threat to a wide range of agricultural and horticultural crops. Its invasiveness is attributed to its prolific reproduction, short life cycle, and ability to thrive in diverse environmental conditions (Mound and Collins, 2000). In recent years, globalization, international trade, and climate change have facilitated its spread to new regions, where it has displaced native thrips species and caused extensive crop damage (Haseeb *et al.*, 2011). This review aims to consolidate current knowledge on the bioecology, host range, and population dynamics of *T. parvispinus*, emphasizing its impact on agriculture and exploring effective management strategies. By understanding the factors contributing to its invasiveness, this article seeks to inform sustainable pest management approaches to mitigate its impact on agricultural ecosystems.

Thrips parvispinus (Karny) - an invasive alien species

Thrips is one of the largest genera in the family Thripidae of the insect order Thysanoptera, with 301 species known globally (Thrips, 2021), 44 of which are reported from India (Rachana and Varatharajan, 2017). *Thrips parvispinus* (Karny) (Tobacco black thrips), is a devastating invasive pest on a variety of agricultural and horticultural crops, is one of the significant invasive pest species of South East Asia. *T. parvispinus* has been spread from Thailand to Australia. It is a member of a "*Thrips Orientalis* group" (Mound and Collins, 2000; Mound and Masumoto, 2005).

Global distribution of *Thrips parvispinus*

T. parvispinus was reported on papaya in Hawaii, *Gardenia* sp. in Greece, vegetable crops like Capsicum, green beans, potato and brinjal from other countries (Murai *et al.*, 2010). *T. parvispinus* has been reported from Southeast Asia to northern Australia and Solomon Islands (Palmer, 1992), extending its area of distribution to the north Yunnan - China (Zhang *et al.*, 2011), Philippines (Reyes, 1994), and Taiwan (Mound and Masumoto, 2005). Sartiami and Mound (2013) reported that, *T. parvispinus* is the most found species that is associated with horticultural plants in Java, with considerable damage to chilli and potato plants. Elijonnahdi *et al.* (2021) observed four species of Thrips *viz.*, *T. parvispinus, T. palmi, T. hawaiiensis,* and *Haplothrips* sp. from the Suborder Tubulifera on chilli plants (*C. annuum*) in West Sumatera, Indonesia. Among the four species *T. parvispinus* was found dominant. Yulianti (2008) reported that, *T. parvispinus* species were found to predominantly infest chilli plantations in the surrounding West Java region, with an average population of 8.18–19.22 thrips/plant.

Indian Scenario of *Thrips parvispinus*

Occurrence of this thrips species in India has been first reported on papaya from Bangalore (Tyagi *et al.,* 2015). In India, *T. parvispinus* was reported for the first time on *Capsicum annuum* in the farmer's fields of Jewargi Taluka, Kalaburagi district of Karnataka region (Basavaraj *et al.,* 2021). Anitha *et al.* (2021) reported the occurrence of this invasive thrips in all the chilli growing districts *viz.,* Warangal, Mahabubabad, Khammam, and Suryapet of Telangana state during November, 2021; and occurrence of this thrips in major chilli growing districts *viz.,* Chitradurga, Bellary, Gadag, Koppal, and Raichur of Karnataka was recorded during November and December, 2021 (Nagaraju *et al.,* 2021). Sireesha *et al.* (2021) reported an outbreak of *T. parvispinus* in chilli growing areas of southern India. Chilli flower thrips were first noticed in Chilakaloripeta and Pratipadumandals of Guntur district of Andhra Pradesh during January, 2021 and subsequently its spread was noticed in all chilli growing areas of Andhra Pradesh. Sridhar *et al.* (2021) examined the outbreak of *T. parvispinus* in India, which displaced the well-established chilli thrips, *Scirtothrips dorsalis* in chilli ecosystems from the states of Andhra Pradesh, Karnataka, and Telangana.

Host plants of *T. parvispinus*

S.No.	HOST PLANTS	COUNTRY	REFERENCES
1.	*Gardenia* sp.	Greece	Murai *et al.* (2010)
2.	Vegetable crops like capsicum, green beans, potato and brinjal	Other countries	
3.	Coffee, *Gardenia* sp., papaya, chilli pepper, sweet pepper, potato, tobacco, *Vigna* sp., green bean, strawberry, eggplant, watermelon, and cucurbits	-	EPPO (2001); Azidah (2011); Moritz *et al.* (2013); Sartiami and Mound (2013)
4.	Pepper, anthurium and hoya	-	Johari *et al.* (2014)
5.	Papaya, peppers, potatoes, egg plants, beans, shallots, crotalaria, *Vigna* sp., coffee, cucumber, tobacco	Indonesia	Hutasoit *et al.* (2017)
6.	Solanaceae and Cucurbitaceae plants	Jambi region, Sumatera, Indonesia	Tasmin *et al.* (2018)
7.	Ornamentals, Citrus, *Dipladenia*, *Ficus benjamina*, Gardenia, Gerbera, and Schefflera	Europe	Lacasa *et al.* (2019)
8.	Anthurium, chrysanthemum, dahlia, dipladenia, gardenia and ficus	-	NPPO (2019)
9.	Bitter gourd and beans	India	Sireesha *et al.* (2021)
10.	Paprika	Telangana, India	Anitha *et al.* (2021)
11.	Chilli	Karnataka, India	Prasannakumar *et al.* (2021)
12.	Gherkins	Kotur (Vijayanagar), Sira and Gubbi taluks (Tumkur), Karnataka, India	
13.	Sunflower, marigold, soybean, coriander, moringa, cotton, amaranth, and green gram	Ranibennuru (Haveri), Karnataka, India	
14.	Broccoli and marigold	Bagalkot, Karnataka, India	
15.	Papaya, peppers, potatoes, eggplants, beans, shallots, and strawberries, dahlia, chrysanthemum, gardenia, *Dipladenia*, *Anthurium*, hoya and *Ficus*	-	Nagaraju *et al.* (2021)
16.	*Parthenium* sp., *Amaranthus* sp., *Axonopus* sp., *Ageratum* sp., *Alternanthera* sp., and *Thunbergia* sp.	-	Nagaraju *et al.* (2021)
17.	Cotton	Coimbatore, Tamil Nadu, India	Amutha and Rachana (2022)

Biology of *T. parvispinus*

T. parvispinus undergoes a metamorphic transition between paurometabola and holometabola. Its development includes five immature stages: egg, two nymphal instars, prepupa, and pupa, with durations of 4.79, 1.36, 3.54, 1.08, and 1.96 days, respectively (Hutasoit *et al.,* 2017). The total life cycle is completed in 13–14 days, with the pre-adult stage lasting 12.97 days in males and 12.57 days in females. The sex ratio of males to females is 1:1.63 (Hutasoit *et al.,* 2017). Environmental conditions influence the reproductive and developmental parameters of *T. parvispinus*. At temperatures of 20°C, 25°C, and 30°C, mean fecundity is reported as 50, 69, and 56 eggs per female, respectively, while the mean generation time is 37.6, 24.8, and 18.8 days. The intrinsic rate of natural increase also varies, measured at 0.18, 0.24, and 0.37, respectively (Murai *et al.,* 2010). The pre-oviposition period is approximately 1.11 days, and the overall life cycle averages 13.68 days. Adult females live for about 8.55 days, while males survive for approximately 6.00 days. Mated females typically live nine days, whereas males have a shorter lifespan of six days (Borror *et al.,* 2005).

Bioecology and factors influencing population dynamics

Egg production of *Thrips* sp. increases if the imago was bred on plants that had a high amino nitrogen content (Ananthakrishnan, 1993). Higgins (1992) stated that most nymphs of *T. parvispinus* is located on the leaves of chilli plants and imago is in the floral part of *C. annuum*. The nymph population is higher in the leaves of large chilli leaves than in flowers. Leaf parts can provide optimal protection and development for nymphs of *T. parvispinus* (Pearsall and Myers, 2000). *T. parvispinus* exhibits colour variation in response to ambient temperature, appearing paler at higher temperatures and darker at lower temperatures (Prabaningrum, 2005). Both nymphs and adults feed on flowers, flower buds, leaves, and small fruits by lacerating plant tissues. Additionally, females are black, while males are yellow, and both sexes have been observed damaging flowers in groups (Basavaraj *et al.,* 2021). The response of pepper plants (*Capsicum annuum* var. *grossum*) to *T. parvispinus* infestations has been linked to plant age. Research by Prabaningrum and Moekasan (2007) found that the thrips population, including both adults and nymphs, correlates with the plant's age at the time of the initial infestation. As plants mature, the concentration of secondary compounds increases, which is believed to hinder egg-laying, reduce thrips survival rates, and ultimately suppress pest development.

High-carbon dioxide atmospheres have been tested as a control method for thrips. Seki and Murai (2012) examined the mortality of five thrips species, including *T. parvispinus*, under 60% CO_2 at different temperatures (20, 25, 30, and 34°C). The results showed that thrips mortality increased with longer CO_2 exposure at each temperature. Notably, exposure to 60% CO_2 at 30°C for 24 hours was 100% lethal to most pests of fresh agricultural produce. This suggests that CO_2 treatment could be an effective method for producing thrips-free plants in horticultural nurseries and for quarantine measures in plant transportation. Host plant abundance and spacing also influence *T. parvispinus* infestation levels. Aryantini *et al.* (2015) reported that a higher density of host plants and closer plant spacing resulted in a higher thrips attack rate, whereas lower plant density and wider spacing reduced pest incidence. Additionally, Thrips species, including *T. parvispinus*, move between different parts of a plant by running, jumping, or flying. The distance between plants plays a crucial role in thrips dispersal and population dynamics (Caroulus, 2017).

The population dynamics of *T. parvispinus* on cayenne pepper (*Capsicum frutescens* L.) are influenced by environmental factors and plant characteristics. Setyawan *et al.* (2017) observed *T. parvispinus* abundance by examining 10 leaves and 10 flowers per plant. The presence of *T. parvispinus* was first detected at three weeks after planting (WAP) in low numbers. The population increased at 4 and 5 WAP, followed by a decline at 6 WAP. However, a resurgence was recorded at 7, 8, and 9 WAP, peaking at 10 WAP. A steady decline in population was observed at 11 and 12 WAP (Sumaradana *et al.,* 2021). Flight activity and population development of *T. parvispinus* on chili plants have also been studied. Pratiwi *et al.* (2018) monitored flight activity using yellow sticky traps placed diagonally on the plants. Their findings indicate that *T. parvispinus* is most active in flight at a light intensity of 4000–6000 lux, which is favourable for thrips movement in greenhouse conditions. However, flight activity decreased when light intensity reached 8000–10,000 lux, particularly between 12:00 and 14:00. The daily flight activity of adult *T. parvispinus* fluctuated throughout the day, with peak activity recorded at 09:00–10:00 (39.81 adults) and the lowest at 18:00–19:00 (9.84 adults). Population distribution differed between plant parts. The nymph population was higher on leaves, with the peak occurring at 12:00–13:00 (21.07 nymphs), while adults were more abundant on flowers, reaching the highest numbers at 18:00–19:00 (27.36 adults). These findings suggest that nymphs prefer residing on leaves, whereas adults are more frequently found on flowers (Liang *et al.,* 2010).

Plant spacing plays a significant role in regulating *T. parvispinus* populations, as it is influenced by environmental factors such as light intensity, temperature, humidity, and rainfall. Wider plant spacing was associated with lower thrips populations in treatment plots, indicating that plant density can impact pest infestations (Dirgayana *et al.,* 2021). Sexual dimorphism in *T. parvispinus* is evident in both size and coloration. Females measure approximately 1 mm in length, with a brown head and prothorax, yellowish-brown meso- and metathorax, and a black abdomen. Their forewings are dark with a lighter-coloured base. Males, in contrast, are smaller at 0.6 mm and uniformly yellow. Larvae are larger than adults, progressing through different instars while maintaining a uniform yellow coloration (Sireesha *et al.,* 2021). Yuliadhi *et al.* (2022) found that the imago population was consistently higher than the nymph population throughout the observation period. The peak imago population was recorded on the first day (112.5 individuals), with a steady decline observed from the fifth to the seventh day, reaching its lowest point at 60.75 individuals. *T. parvispinus* was reported to damage all parts of the large chili plant, particularly flowers and leaves. Severe infestations resulted in leaves developing silvery to brownish spots and curling upwards, while affected flowers withered and eventually fell off.

Damage potential of *T. parvispinus*

The damage inflicted by *T. parvispinus* on chili leaves is characterized by the appearance of silvery spots (Prabaningrum and Moekasan, 1996). In severe infestations, these spots may turn brown, and the leaves begin to curl upwards (Vos *et al.,* 1991). Additionally, *T. parvispinus* is known to act as a vector for the Tobacco streak virus (TSV), contributing to significant losses in chili cultivation, with yield reductions reaching 22.8% (Sastrosiswojo, 1991). Thrips infestations also have physiological effects on plants. Ellsworth et al. (1995) reported that thrips attacks could reduce the photosynthesis rate by up to 20%. Moreover, thrips feeding activity stimulates the production of ethylene, a plant hormone that can lead to premature shedding of affected plant parts (Childers and Achor, 1995). For instance, long bean flowers infested with three adult thrips and six nymphs of *Megalurothrips* exhibited a significant increase in ethylene production four days after infestation. Infected flowers produced 640 nmol/g/24 h of ethylene, compared to only 152 nmol in healthy flowers. Similarly, Rieske and Raffa (1995) found that ethylene production in *T. calcaratus* -infested American basswood tissue was 2.2 times higher than in tissue damaged by physical factors and three times higher than in undamaged tissue.

In paprika plants, thrips damage was positively correlated with pest population density, indicating that higher thrips populations result in greater plant damage. The major symptoms of *T. parvispinus* includes deep punctures and scratches on under-side of the leaves gives reddish brown colour and corresponding upper portion turns yellow. Distorted leaf lamina with necrotic areas and yellow streaking was also observed. If the infestation is severe on newly emerging leaves, such leaves are dried/blighted. Portions adjacent to veins are preferred. Thrips feeds on pollen which may affect pollination, leading to drying and withering of flowers and fruit set gets affected (Sireesha *et al.*, 2021). Sridhar *et al.* (2021) reported 80-100 per cent yield loss to chillies in the southern states of India. They also carried out systematic surveys in the states of Andhra Pradesh, Karnataka and Telangana, and revealed that *T. parvispinus* completely dominated the thrips species generally observed in chilli mainly, *S. dorsalis*.

Integrated Management of *T. parvispinus*

Cultural Control

Implementing proper agricultural practices can play a crucial role in minimizing the spread of *T. parvispinus*. Ensuring the use of healthy, pest-free seedlings and promptly removing infected plants can help control infestations, while severely affected areas should be cleared to prevent further spread (Sridhar *et al.,* 2021). Growing crops away from infested fields and eliminating weed hosts also contribute to reducing damage. Field management strategies should also include the collection and destruction of infested crop debris, as well as the removal of off-season host weeds like *Parthenium* spp. and *Abutilon* spp.. Interestingly, studies have shown that *T. parvispinus* populations tend to concentrate in coriander flowers, suggesting that coriander can be effectively used as a trap crop to divert thrips away from more vulnerable plants (Prasannakumar *et al.,* 2021).

Certain pepper accessions, such as *Capsicum 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, have shown resistance to *T. parvispinus* and *Frankliniella occidentalis*, making them valuable resources for resistance breeding programs (Maharijaya *et al.,* 2011). In chilli cultivation, a system incorporating plastic mulch, avoiding intercropping, and applying pesticides resulted in the lowest *T. parvispinus* population during the vegetative stage (Haerul *et al.*, 2020). Beyond plant selection, maintaining balanced fertilizer application and minimizing excessive nitrogen use can help reduce thrips infestations (Sireesha *et al.,* 2021). Adopting crop rotation and diversification strategies can effectively disrupt the thrips life cycle by removing their preferred host plants, ultimately reducing their populations (Rodríguez and Coy-Barrera, 2023). Habitat manipulation techniques, such as using straw mulch and flower strips, create unfavourable conditions for thrips while encouraging natural predators, leading to better pest control and improved crop yields. Additionally, tillage practices like strip tillage have been shown to lower thrips densities and feeding damage compared to conventional tillage, reducing the occurrence of thrips-transmitted diseases such as spotted wilt in crops like peanuts (Marasigan *et al.,* 2018). Combining these cultural practices with the use of resistant cultivars offers an integrated approach to managing thrips populations and mitigating crop damage, particularly in crops like potatoes (Setiawati *et al.,* 2010). Rahardjo *et al.* (2021) conducted a study to evaluate the resistance of 12 Chrysanthemum genotypes to

Thrips parvispinus. The research included 10 IOCRI mutant genotypes and two introduced varieties, Yellow Fiji and White Fiji. Among these, the 'Mayang Ratih' genotype demonstrated moderate resistance, exhibiting the lowest pest attack intensity and the highest yield of harvestable flowers while maintaining an optimal flower diameter. These characteristics make 'Mayang Ratih' a promising candidate for breeding programs focused on developing thrips-resistant Chrysanthemum varieties. Further, it was also confirmed that the Mayang Ratih genotype of chrysanthemum exhibited resistance to *T. parvispinus*, making it a promising candidate for future breeding efforts (Musalamah *et al.,* 2021).

Physical and Mechanical Control

Managing *T. parvispinus* infestations effectively requires a combination of physical and mechanical control methods to minimize reliance on chemical pesticides. Mechanical removal techniques, such as washing plants with liquids, manually knocking off thrips, or using chemical vapours and heat, provide non-chemical alternatives for pest control (Ota, 1968). Exclusion nets can also act as a physical barrier to prevent thrips from reaching crops; however, their effectiveness varies depending on the crop. For instance, studies on onion cultivation found that exclusion nets negatively affected yields, emphasizing the need for careful evaluation before implementation.

Research on physical measures has also demonstrated promising results. Exposure to an environment with 60% CO_2 at 30°C resulted in 100% mortality of multiple thrips species, including *Frankliniella occidentalis*, *F. intonsa*, *T. tabaci*, *T. palmi*, and *T. parvispinus* (Seki and Murai, 2012). The effectiveness of colour traps has been studied extensively, with findings indicating that *T. parvispinus* is more attracted to white traps than blue or yellow ones (Murai *et al.,* 2010). However, blue and yellow sticky traps have been found to capture more adult *T. parvispinus*, making them useful tools for thrips monitoring and mass trapping (Sireesha *et al.,* 2021). Installing 25–35 blue sticky traps per acre immediately after transplanting has been recommended for effective thrips population control. By integrating these physical and mechanical control methods, farmers can enhance pest management strategies while reducing the environmental impact of chemical insecticides.

Biological Control

Controlling *T. parvispinus* on paprika plants can be effectively achieved using natural predators like *Amblyseius swirskii* and *Orius laevigatus*. Research by Prabaningrum and Moekasan (2010) tested the efficacy of these predators in a screen house experiment, using four treatments: *A. swirskii* (75/m^2), *O. laevigatus* (5/m^2), a combination of *A. swirskii* (40/m^2) and *O. laevigatus* (3/m^2), and a control group without predators. The study found that *A. swirskii* reduced thrips populations by more than 50%, decreased plant damage by 50%, and helped maintain pepper yields by approximately 30%. These findings suggest that incorporating these predators into pest management strategies could reduce reliance on insecticides for paprika farmers.

The infestation of *T. parvispinus* in chrysanthemums makes lower flower quality and disrupt exports. Yusuf *et al.* (2010) examined the effectiveness of *Beauveria bassiana*, a fungal biopesticide, in reducing thrips populations. The study tested different carriers, including corncob flour, talc, and husk ash, along with *B. bassiana* 10^9conidia/ml, Beauveria N (positive control), and water (negative control). Among these, *B. bassiana* with a talc carrier proved to be the most effective, significantly suppressing thrips populations and minimizing flower damage better than the commercial control. In contrast, corncob flour and husk ash carriers were less effective.

Post-harvest protection is just as crucial for chrysanthemums, especially when dealing with *T. parvispinus*. A study by Setyawan *et al.* (2017) explored the use of liquid phosphine fumigation to eliminate thrips from cut flowers. Their research demonstrated that a 200 ppm concentration applied for one hour achieved 100% mortality without causing physical damage or wilting, even when exposure extended to six hours. This method offers a safe and effective way to maintain flower quality while eliminating pests. Another approach to pest control focuses on altering thrips development through plant growth-promoting rhizobacteria (PGPR). Hutasoit and Sitanggang (2018) studied the effects of PGPR which consist of *Rhizobium, Paenibacillus polymyxa*, and *Pseudomonas fluorescens* on the life cycle and reproduction of *T. parvispinus* on chili peppers. The results showed that PGPR-treated plants slowed the thrips development, shortened their lifespan, and significantly reduced reproductive rates, making PGPR a promising tool for integrated pest management.

Natural predators like *Coccinella transversalis* also play a role in thrips control. Jayanti *et al.* (2018) investigated this lady beetle preys on *T. parvispinus*, analysing its search time, handling time, and overall predation efficiency. Their findings revealed that as thrips density decreased, the time required for the predator to locate its prey increased. On average, a single beetle took 1.4 minutes to handle each thrips and consumed approximately 58.67 thrips per day, highlighting its potential as a biological control agent.

In addition to predators, parasitoids also contribute to natural thrips control. Sumaradana *et al.* (2021) studied the impact of natural enemies on *T. parvispinus* populations in cayenne pepper (Capsicum frutescens). They identified two key predators, *Chrysoperla carnea* (23.3 individuals on average) and *C. transversalis* (22.4 individuals on average) as well as the parasitoid *Ceranisus* spp., which emerged from *T. parvispinus* nymphs at an average rate of 10.2 individuals per 100 nymphs. These findings underscore the importance of beneficial insects in managing thrips populations in chili pepper fields.

Chemical Control

Chemical control continues to play a crucial role in managing *T. parvispinus*, especially when used alongside cultural and biological methods. Research has shown that spraying insecticides like fipronil 80WG (0.2 g/L), cyantraniliprole (1.25 mL/L), acetamiprid (0.2 g/L), and spinosad (0.3 mL/L) on a weekly basis can effectively reduce thrips populations (Kumari *et al.,* 2021). However, to maintain effectiveness and prevent the development of resistance, it's important to rotate insecticides with different modes of action (Sugano *et al.,* 2013). Studies suggest that alternating fipronil, cyantraniliprole, acetamiprid, and spirotetramat at recommended application rates can improve pest control outcomes (Sireesha *et al.,* 2021). Among these, spinosad 45% SC has been identified as the most effective and cost-efficient option (Neelofor and Kumar, 2022). Despite these advantages, overuse of insecticides can sometimes lead to thrips resurgence, particularly in chili crops (Sireesha *et al.,* 2021). Several conventional insecticides have proven to be highly effective against *T. parvispinus*. Chlorfenapyr, sulfoxaflor-spinetoram, and spinosad have significantly reduced thrips populations and minimized leaf damage in various studies. Other insecticides, such as broflanilide, fluxametamide, tolfenpyrad, spinetoram, and fipronil, have also demonstrated strong results in laboratory tests, with broflanilide showing up to 93.3% mortality (Manideep *et al.,* 2023). Field studies further support these findings, with spinosad reducing thrips numbers by 80.2% in chrysanthemum crops. Meanwhile, imidacloprid, when applied at 100 L ha^{-1}, effectively controlled *T. parvispinus* infestations in red chili fields while remaining safe for natural enemies (Supartha *et al.,* 2022). These findings highlight the effectiveness of both contact and systemic insecticides in controlling thrips across different crop types.

Botanicals in Pest management

Various botanical and mineral-based treatments have demonstrated significant efficacy in controlling *T. parvispinus* infestations. Mineral and sesame oils effectively reduce thrips mortality and minimize leaf-feeding damage in both direct and residue toxicity assays. Similarly, neem oil, pongamia oil, and soap-based treatments have shown promising results, particularly in areas with severe infestations. Pongamia soap significantly reduced thrips incidence in field conditions, achieving a 74.90% reduction, while neem oil extract proved effective in controlling thrips and considered as a viable alternative to synthetic insecticides (Manideep *et al.,* 2023). Additionally, plant-derived treatments such as fish poison bean (*Tephrosia vogelii*) at 2.5% and 3.0%, Indonesian mahogany (*Toona sureni*) at 3.0%, and eucalyptus oil at 2.0% exhibited over 30% effectiveness during the vegetative stage. These treatments maintained minimal *T. parvispinus* infestations up to 75 days after planting (DAP) and contributed to higher yields of marketable chrysanthemum flowers (Rahardjo *et al.*, 2021).

CONCLUSION

T. parvispinus poses a serious threat to agriculture due to its broad host range, high reproductive potential, and adaptability. Its rapid spread causes significant crop losses, demanding urgent management solutions. Integrated pest management (IPM) with biological control, cultural practices, and eco-friendly biorationals offers a sustainable approach. Further research on resistance mechanisms and novel biocontrol agents is essential for long-term management. Collaborative efforts involving research, farmers, and policymakers are crucial to mitigate its impact and ensure agricultural sustainability.

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