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Rapid assessment of a thrips outbreak on shallots in Brebes and Tegal, Central Java Province, Indonesia

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Abstract. *Ananda S, Triwidodo H, Anwar R, Sartiami D. 2024. Rapid assessment of a thrips outbreak on shallots in Brebes and Tegal, Central Java Province, Indonesia. Biodiversitas 25: 5024-5030.* One of the high-economic-value crops extensively cultivated by farmers in Indonesia is shallots. The cultivation of shallots often faces problems from plant pests and diseases, which can decrease productivity. One of the pests infesting shallots is thrips. In September 2023, a thrips outbreak was reported in shallot fields in Brebes and Tegal Districts, Central Java Province, Indonesia, causing significant losses for farmers, with severe infestations leading to crop failure. Typically, the beet armyworm *Spodoptera exigua* (Lepidoptera: Noctuidae) is the primary pest causing significant losses in shallot commodities in Brebes and Tegal. Prior to 2023, thrips were considered secondary pests and rarely caused severe damage. This research aims to investigate the history of thrips infestations based on interviews with 40 farmers, determine the pest population level using pest counts, and identify thrips to species. The research findings indicate that while farmers' knowledge about thrips still needs to improve, there is a significant potential for enhanced thrips management. The farmers' knowledge, perspective, and actions significantly affect the thrips population in the fields. Farmers in Tegal exhibited more thorough knowledge of thrips management than those in Brebes, where thrips populations were higher. Climatic factors, such as increased temperatures and decreased rainfall, contributed to the rise in the thrips population. Farmers' adaptation strategies to cope with thrips outbreaks include increasing the frequency and dosage of pesticide spraying, early harvesting, and abandoning infested fields, which results in crop failure. The thrips species causing shallot damage in Brebes and Tegal was *Thrips tabaci* (Thysanoptera: Thripidae).

Keywords: Climate, farmers, identification, population, *Thrips tabaci*, Thysanoptera

INTRODUCTION

Shallots (*Allium ascalonicum* L.) are essential to food security in Indonesia, mainly due to their extensive use in local cuisine and their significant economic contribution to agriculture. Classified as a high-value horticultural crop, they are a key source of income for many farmers (Prakoso and Alpandari 2022). Central Java Province is one of Indonesia's largest producers of shallots, with Brebes and Tegal being the primary production areas within the province (Ministry of Agriculture 2023). Shallots play a crucial role in farmers' economic livelihoods in these regions due to their distinctive flavor and importance in local cuisines. The demand for shallots is increasing, driven by population growth and the expanding shallot processing industry (Taufiq et al. 2021). In 2022, the harvested area for shallots in Brebes was 32,571 hectares, producing 384,448 tons, with a productivity rate of 11.8 tons per hectare. Meanwhile, in Tegal, the production reached 10,829 tons, with a harvested area of 1,202 hectares. According to data from BPS (2022), shallot productivity in 2022 decreased by 1.51% compared to the previous year.

The attack of plant pests is one of the factors that can lead to a decrease in shallot production. Common pests in shallot crops include leafminers (*Liriomyza* spp.), beet armyworms (*Spodoptera exigua* Hübner, 1808), thrips (*Thrips tabaci* Lindeman, 1889 and *Thrips parvispinus* Karny, 1922), and black cutworms (*Agrotis ipsilon* Hufnagel, 1766) (Prastowo and Sukarno 2020). Thrips are tiny insects in the order Thysanoptera, characterized by their rasping-sucking, asymmetrical mouthparts, two pairs of fringed wings, and minute size. Many thrips species have a broad host range and can attack various food crops and horticultural plants (Varela and Fail 2022). Thrips damage plants directly through their feeding activity, which involves sucking plant cell fluids, and indirectly by serving as vectors for plant viruses (Rotenberg et al. 2015). This feeding activity results in symptoms like silvery spots, which expand into blotches as the leaves grow. These blotches develop into larger silvery patches, often leading to leaf curling (Boateng et al. 2014). This damage reduces the plant's photosynthetic capacity and may disrupt nutrient transport to the bulbs. Severe infestations can reduce shallot yields by more than 50% (Shonga and Getu 2018). The pest most frequently causing losses in shallot commodities in Brebes and Tegal is the beet armyworm, *S. exigua* (Lepidoptera: Noctuidae). However, in September 2023, a thrips outbreak was reported in several shallot-growing regions. Thrips infestations have been increasingly reported, particularly during the dry season, when conditions favor their proliferation. Previously, thrips were considered secondary pests and rarely caused severe damage. This underlines the importance of proactive prevention strategies in pest management.

According to Taherkhani (2022), climate factors, particularly temperature and humidity, significantly influence insects' biological processes and activities. These factors induce changes in growth rates and metabolic intensity and either extend or shorten the insect's lifespan, affecting the number of generations and developmental patterns. Environmental conditions are one of the primary factors contributing to insect outbreaks, with any unplanned changes directly impacting all aspects of insect life. The role of environmental parameters can shape biological processes, affecting insect physiology. Prolonged dry periods and high temperatures create an ideal environment for thrips to thrive (Moraiet and Ansari 2014). Thrips have a short life cycle; populations can increase exponentially in weeks under favorable conditions. Because of that, it necessitates early detection and rapid assessment of infestations to implement timely control measures. However, in many cases, farmers may need more knowledge or resources to accurately monitor pest populations, resulting in delayed or inadequate responses to outbreaks (Nining et al. 2019).

Conducting field surveys and interviews with local farmers aims to understand the dynamics of the 2023 outbreak and identify gaps in existing pest management strategies. Understanding the causes of pest outbreaks and the pest species within the shallot ecosystem is crucial for developing effective, environmentally friendly, and sustainable pest management strategies. This research aims to investigate the chronologies of thrips outbreaks based on information from farmers, examine how farmers mitigate and adapt to the outbreak, and identify the species of thrips attacking shallot plants in Brebes and Tegal.

MATERIALS AND METHODS

Time and place of research

This research was conducted from October 2023 to May 2024. The research sites were shallot plantations in Brebes District and Tegal District, Central Java Province, Indonesia. Thrips identification was performed at the Biosystematics Laboratory, Department of Plant Protection, Institut Pertanian Bogor, Bogor, Indonesia.

Procedures

Determination of respondent farmers and sample points

The criteria for respondent selection were shallot farmers aged over 20 years, with a total of 40 respondents, comprising 20 farmers from Brebes and 20 from Tegal, Central Java. Respondents were selected using purposive sampling, targeting farmers with fields infested by thrips. The research fields consisted of shallot crops at various growth stages. Observations and data collection were conducted at three sampling points within each shallot field, with the sampling points chosen in areas affected by thrips infestation. Subsequently, interviews with farmers were conducted using a structured questionnaire designed to assess the farmers' knowledge, attitudes, and behavior in managing thrips in shallot cultivation. The questionnaire included questions about the farmers' characteristics and perceptions of thrips.

Thrips population observation

Thrips observations in the crop fields were conducted at each sampling point. Observations were made at three sample points per field, with 20 fields in Brebes and 20 in Tegal, resulting in 120 sample points overall. The sampling points were determined using purposive sampling, specifically targeting areas with known thrips infestations. Thrips observations were made by beating the leaves of the plants over a plastic container or tray at each sampling point, with ten beats per point. The insects collected were then placed in collection containers, and their numbers were recorded. Each collection container was labeled with information including the date, location, and the number of thrips observed. The thrips collected were subsequently taken to the laboratory for identification. The level of damage to the shallot plants was assessed by scoring the affected plants at each sampling point. According to Maniania et al. (2003), plant damage by thrips can be evaluated using a scoring system, categorized into five levels: 1: no apparent damage; 2: light damage ($x \leq 25\%$); 3: moderate damage ($25 < x \leq 50\%$); 4: heavy damage ($50 < x \leq 75\%$); 5: very heavy damage ($x > 75\%$).

The intensity of thrips attacks uses the formula:

$$I = \frac{\sum_{i=1}^{k} (ni \times Vi)}{N \times Z} \times 100\%$$

Where: n_i: the number of leaf attack; v_i: score in each attack category; N: number of leaves observed; V: score for the heaviest attack category.

Thrips identification

Thrips were identified at the species level by analyzing their morphological characteristics using a permanent microscope slide. The slides were prepared following a modified version of the method described by Mound and Kibby (1998). The identification key used is a book by Mound and Kibby (1998) and Lucid Key Central to identify the thrips species.

Data analysis

Observation data were tabulated using Microsoft Excel 365. The correlation between farmers' knowledge, attitudes, and behavior regarding thrips in the field was analyzed using the Spearman correlation test to assess the relationships between these variables with RStudio software.

RESULTS AND DISCUSSION

Farmers' characteristics

More than 50% of farmers actively engaged in cultivation activities are over 40 years old, with the majority over 50 (Table 1). Age is one of the factors contributing to success in agricultural activities. According to Brown et al. (2019), age influences farming objectives and management decisions. Older farmers tend to be more risk-averse, less inclined to adopt new technologies or experiments, and less susceptible to social influences, focusing primarily on financial outcomes.

Table 1. Farmer's characteristics in Tegal and Brebes Districts, Central Java Province, Indonesia

Characteristics	Brebes (n: 20)		Tegal (n: 20)	
	Number	%	Number	%
Age				
<40 years	5	25	1	5
41-50 years	8	40	4	20
>50 years	7	35	15 (most-older)	75
Education				
Below elementary	5	25	9	45
Elementary school	10	50	9	45
Junior high school	5	25	0	0
High school	0	0	2	10
Category of land				
Self-owned land	5	25	2	10
Rented land	15	75	16	80
Sharecroppers	0	0	2	10
Farming experience				
<20 years	3	15	1	5
21-30 years	7	35	9	45
>30 years	10	50	10	50
Land area				
<0,5 hectare	12	60	15	75
0.5-1 hectare	7	35	5	25
>1 hectare	1	5	0	0
Origin of knowledge				
Parents	16	80	13	65
Other farmers	3	15	7	35
Self-learning	1	5	0	0
Origin of seeds				
From previous production	18	90	15	75
Bought from other farmers	2	10	5	25

In contrast, younger farmers are generally more open to experimentation, more willing to take risks, and equally focused on financial performance. The characteristics of the respondent farmers indicate that the majority have an educational background of elementary school or below elementary. In terms of land ownership, approximately 25% (Brebes) and 10% (Tegal) of the respondent farmers cultivate shallots on self-owned land, about 75% (Brebes) and 80% (Tegal) on rented land, and the remaining farmers are sharecroppers.

Land rental rates in Tegal are higher than in Brebes. Farmers in Tegal generally reside in Brebes, which leads them to rent land in Tegal. The location of rented land often changes after several seasons. Farmers in both Tegal and Brebes generally have more than 30 years of farming experience, with the highest percentage reaching 50%. That indicates that the farmers have been cultivating crops since their youth. Most of the farming knowledge is inherited from their parents. In addition to this inherited knowledge, farmers gain insights from other farmers or through self-learning based on experience.

Generally, farmers in the Brebes and Tegal use the Bima Brebes variety of shallots, as it is perceived to be easily accessible and yields good-quality bulbs. Farmers typically cultivate shallots in their vegetative form. Farmers continuously use tubers from previous production to reduce costs compared to purchasing from external sources. However, according to Saidah et al. (2020), the continuous use of shallot seeds from one's harvest may diminish both the quality of the bulbs and the quantity of the harvest. Ideally, the seeds should be certified with genetic, physiological, and health qualities that meet the required standards.

Farmers' knowledge, attitude, and behavior about thrips

Generally, farmers were not familiar with the term "thrips". Thrips are known by various local names among farmers, such as *mreki, gurem,* and *janda pirang*. Farmers are more familiar with the symptoms of thrips infestations on chili plants than on shallots, as thrips infestations on shallots are less common. Farmers in Tegal have a higher knowledge level about thrips than farmers in Brebes. However, farmers in Brebes are more aware of the symptoms of thrips infestation and the suitable pesticides for controlling thrips. Some farmers were able to identify thrips symptoms, such as silvery leaf spots that turn into white blotches. Farmers' knowledge of suitable pesticides for controlling thrips is relatively low. Most farmers tend to use pesticides recommended by other farmers. According to Geremias et al. (2022), pesticides such as formetanate hydrochloride, spinetoram, abamectin, thiamethoxam, and imidacloprid can be used to control *T. tabaci* in onions.

In terms of awareness, farmers in Brebes are more conscious of the importance of thrips control compared to those in Tegal. This heightened awareness in Brebes may be due to the higher incidence of thrips infestations in Brebes, prompting farmers to prioritize pest control measures in their fields. The percentage of farmers who consistently control thrips is 35.5% in Brebes and 35.0% in Tegal. The variables of farmers' knowledge, attitudes, and behavior in Brebes were significantly associated with thrips populations in fields. However, in Tegal, only the behavior variable influences thrips populations in the farmers' fields (Table 2). The results show a negative correlation between thrips control measures negatively correlate with the thrips population. Farmers who actively control thrips tend to have lower thrips populations than those who do not.

The knowledge, attitude, and behavior variables of farmers in Tegal do not exhibit any correlation (Table 3). However, in Brebes, there is a correlation between farmers' knowledge, attitude, and behavior regarding thrips management. All observed variables demonstrate a positive or direct relationship, indicating that the level of farmers' knowledge tends to influence their attitudes and behavior. The correlation among knowledge, attitude, and behavior variables demonstrates a relatively strong relationship. Changes in farmers' attitudes correspond to changes in their behavior.

Observation of thrips population

The population of thrips in Brebes is higher compared to Tegal. In Brebes, 1,084 thrips were caught, whereas in Tegal, the count was 404 thrips. The average number of thrips per sample point was 54 in Brebes and 20 in Tegal. Based on the categorization of plant damage, most fields in Tegal experienced light damage (65%), whereas in Brebes, a higher proportion of fields experienced moderate damage (35%) (Figure 1). Based on the plant damage score, the calculated pest infestation intensity was 70% in Brebes and 50% in Tegal.

Table 2. The correlation between farmer knowledge, attitudes, and behavior to the thrips

Statements	Brebes				Tegal			
	Percentage (%)			P-value	Percentage (%)			P-value
	Agree	Neutral	Disagree		Agree	Neutral	Disagree	
Knowledge: I know								
Knowing about thrips	10.0	30.0	60.0	0.003**	20.0	40.0	40.0	0.920
Knowing thrips symptoms	50.0	25.0	25.0	0.038*	15.0	70.0	15.0	0.902
Knowing the type of pesticides for thrips	30.0	35.0	35.0	0.007**	5.0	35.0	60.0	0.435
Attitude: I believe								
Thrips attack need to be controlled	75.0	20.0	5.0	0.017*	55.0	45.0	0.0	0.203
Behavior								
Farmers already control thrips in the field	35.5	30.0	35.0	0.002**	35.0	20.0	45.0	0.017*

Note: *Correlation is significant at the 0.05 level; **Correlation is significant at the 0.01 level

Table 3. Results of correlation analysis of farmers' knowledge, attitudes, and behavior

Variables	Location	Spearman correlation	Knowledge	Attitude	Behavior
Knowledge	Brebes	Correlation coefficient	1	0.561**	0.575**
		Sig. (2-tailed)		0.010	0.007
		N	20	20	20
	Tegal	Correlation coefficient	1	0.218	0.288
		Sig. (2-tailed)		0.356	0.217
		N	20	20	20
Behavior	Brebes	Correlation coefficient	0.575**	0.555*	1
		Sig. (2-tailed)	0.007	0.011	
		N	20	20	20
	Tegal	Correlation coefficient	0.288	0.131	1
		Sig. (2-tailed)	0.217	0.580	
		N	20	20	20

Note: *Correlation is significant at the 0.05 level; **Correlation is significant at the 0.01 level. Data in parentheses are significant level

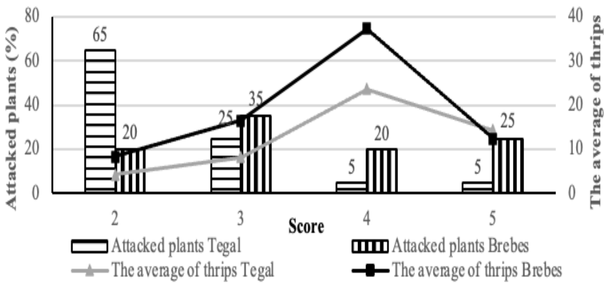

Figure 1. Percentage of plant damage and thrips population

The difference in thrips population between Brebes and Tegal may be attributed to the characteristics of shallot fields in Brebes. In Brebes, shallot fields are typically monocultures spanning tens of hectares and managed by various farmers. In addition, separate planting causes the lifespan of shallot plants to vary, which can encourage an increase in pests. This is supported by Li et al. (2019), who found that a continuous supply of hosts, a low proportion of crop harvested, and long residue times between harvest and replanting exacerbate pest levels. Meanwhile, in Tegal, shallot fields are scattered across the landscape, and farmers also tend to plant various other crops, such as corn and chili.

The initial symptoms of thrips infestation in shallot plants include silvering or bleaching of the leaf surface. That occurs due to thrips puncturing the epidermal cells and sucking out the contents, leaving behind air-filled empty cells, which create a silvered appearance. In cases of severe infestation, the plants exhibit symptoms such as leaf drying and curling. Farmers commonly refer to this condition as *janda pirang* (blonde widow) due to the drooping and yellowish-brown discoloration of the leaves (Figure 2). Dinakaran et al. (2013) reported a similar condition in India, where severe thrips infestation in shallot plants showed several symptoms, such as browning and scorching of the leaves.

The effect of climate change and weather on the increase in pest populations

Climate influences crops and their pests both directly and indirectly. Increases in temperature, atmospheric CO_2 levels, and changes in rainfall patterns are the primary climatic factors affecting pest outbreaks in crops (Skendžić et al. 2021). The average temperature increased from 2022 to 2023, mainly from September to December. In September 2022, the average temperature in Tegal was 32.7°C; by 2023, it had risen to 33.5°C (Figure 3).

Figure 2. Severe symptoms in shallot at Brebes and Tegal Districts, Central Java, Indonesia: A. Heavy damage; B. Very heavy damage; C. Shallot plantation condition

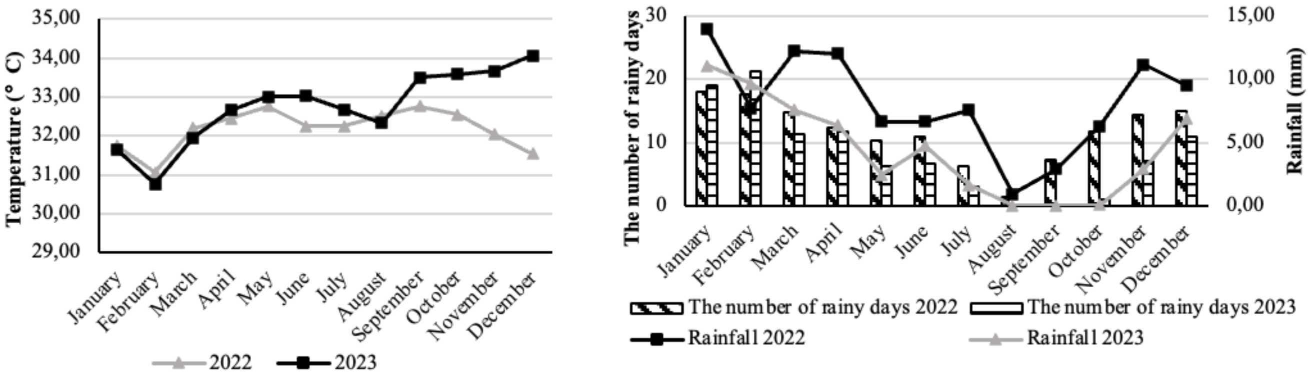

Figure 3. Average temperature, the number of rainy days, and rainfall in 2022 and 2023

In addition to the increase in average temperature, Brebes and Tegal also experienced a decline in rainfall and the number of rainy days. In September 2022, there were seven rainy days with a total rainfall of 3.91 mm; however, in 2023, no rainy days were recorded (Figure 3). According to Chen et al. (2019), rainfall can impact insect survival, development, and diversity. The rise in surface temperature and decrease in rainfall were attributed to the El Niño phenomenon. El Niño is an ocean-atmosphere interaction characterized by the warming of sea surface temperatures in the central and eastern tropical Pacific (Rojas et al. 2019). According to Cai et al. (2014), El Niño significantly influences global and regional rainfall patterns, resulting in increases or decreases in precipitation depending on location and season. The El Niño phenomenon also affects surface and air temperatures in various regions, contributing to global temperature increases and anomalies across many land and ocean areas.

The increase the thrips population coincided with rising temperatures and decreasing rainfall, suggesting that climate factors are one of the primary drivers of thrips population outbreaks. Pest development is influenced by climate factors, both directly and indirectly. Rising temperatures tend to accelerate insect feeding rates, development, and movement, affecting population dynamics. Climate change also impacts plants' innate immunity, leading to stress and making them more susceptible to pests and diseases (Son and Park 2022).

Farmers' adaptation and mitigation of the outbreak

All farmers reported that they had never experienced a thrips infestation of this scale. The primary method of prevention and control employed by the farmers was chemical control using synthetic pesticides, such as those containing the active ingredient broflanilide. Pesticide spraying was conducted as a preventive measure and a control strategy to protect crops from pest attacks. Other control efforts included increasing the frequency and dosage of pesticide applications. Farmers preferred synthetic pesticides because they believed this method was more effective, economical, offered various options, and was easier to apply. Most importantly, synthetic pesticides were perceived to reduce pest populations more rapidly than other control methods. According to Triwidodo (2020), the usage of pesticides weakens the system the population of beneficial organisms, including natural enemies of insect pests, becomes lower and unable to protect the system. Continuous pesticide application, incorrect dosing, and the use of pesticides with the same mode of action can lead to increased resistance in pest populations. As a result, pesticides become ineffective, and pest management practices are unsustainable (Carvalho et al. 2015). A comprehensive approach that combines multiple management strategies is essential for controlling thrips populations while maintaining high crop quality. Implementing an Integrated Pest Management (IPM) strategy for thrips can reduce costs and minimize the use of synthetic insecticides without compromising crop quality and productivity (Hutapea et al. 2024).

Another approach the farmers took was early harvesting, remarkably when the crop damage exceeded 50%. Typically, shallots are harvested at 55-60 days, but some farmers opted to harvest before the plants reached 50 days of age. This practice resulted in smaller bulbs than expected, reducing potential economic gains for the farmers. Some farmers chose not to implement any control measures if the pest attack occurred when the plants were still young (around 20 days), leaving their fields abandoned.

Thrips identification

The thrips species found in both districts is *T. tabaci*. These thrips, commonly known as the onion thrips, belongs to the Order Thysanoptera, Suborder Terebrantia, Family Thripidae, and Genus *Thrips*. The morphological characteristics of *T. tabaci* include a yellow-colored body in the adult or imago stage (Figure 4.A), while the nymph and prepupa stages are white. According to Gill et al. (2015), the adult *T. tabaci* has a variety of body colors, from yellow to brown.

Several factors influence the color variation in thrips, including genetic variation or strain, environmental factors, host plants, and seasonal changes (Mound and Teulon 1995). The antennae of *T. tabaci* consists of seven segments (Figure 4.B). The posterior margin of the pronotum has three to four pairs of setae (Figure 4.C). The metanotum of *T. tabaci* exhibits irregular reticulation, with lines merging near the posterior margin and a short median seta emerging behind the anterior margin (Figure 4.D).

The adult thrips have uniformly colored forewings and hindwings. The wings possess complete setae along the first and second veins of the forewings. The abdomen of *T. tabaci* is composed of ten segments. A key feature that distinguishes this species from other thrips species is the absence of discal setae on the pleurotergites, a unique characteristic (Figure 4.E). The presence of closely spaced rows of fine microtrichia further aids in species differentiation. The median abdominal setae on the sternites are located only on the posterior margin (Figure 4.F). Additionally, this species lacks paired campaniform sensilla on the anterior tergite of the ninth abdominal segment. The eighth segment of the female's abdomen has a saw-like ovipositor.

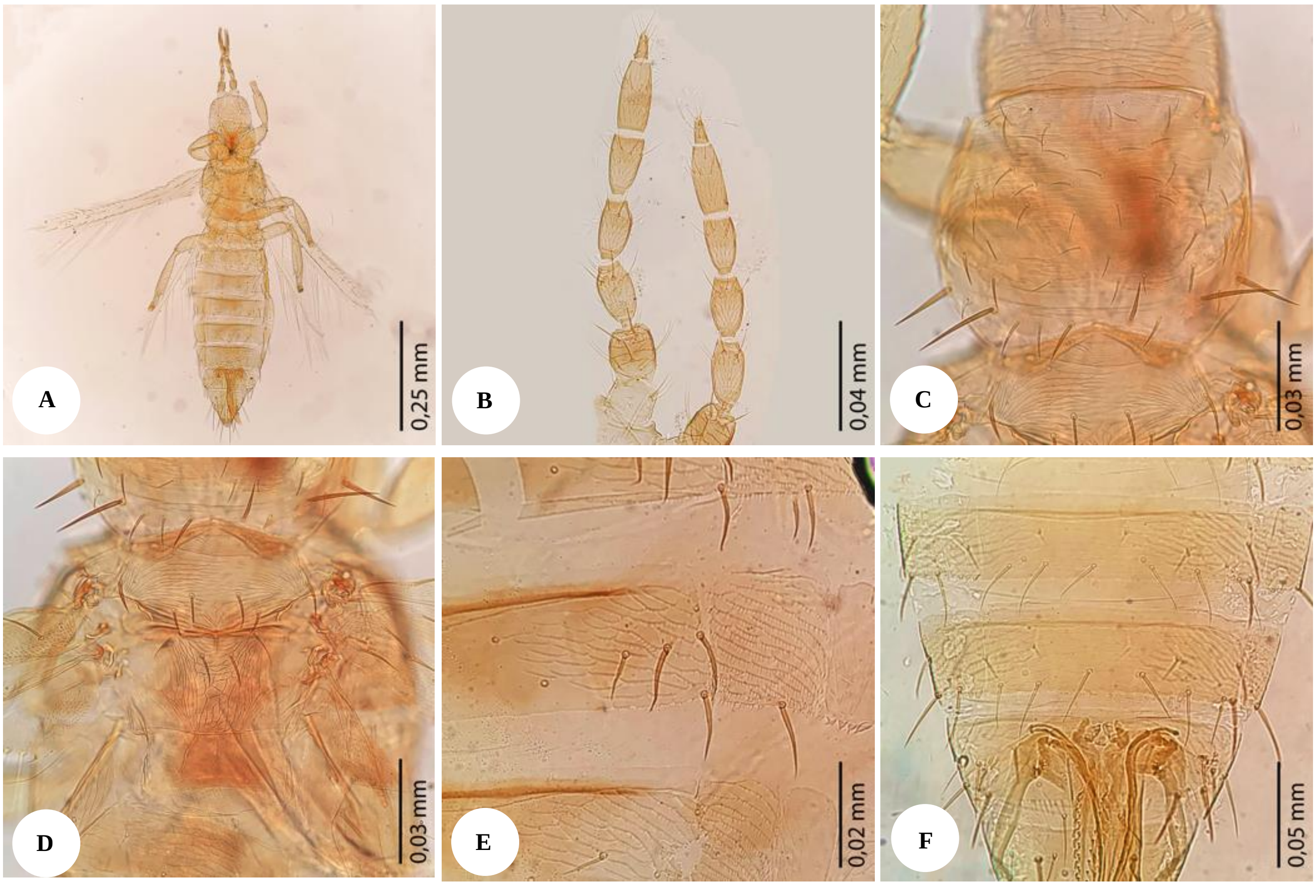

Figure 4. Morphological characteristics of *Thrips tabaci:* A. Full body; B. Antenna; C. Pronotum; D. Mesonotum and metanotum; E. Pleurotergites; F. Sternites

The increase in the population of thrips, originally a secondary pest, in Brebes and Tegal has not occurred previously. The thrips population in Brebes is higher than in Tegal, as is the intensity of the infestations. Farmers' knowledge of thrips pests in both districts needs to be higher, although most have implemented control measures. The majority of farmers rely on chemical control methods by spraying synthetic pesticides to manage thrips in their fields. These control efforts influence thrips populations, with farmers who implement control measures having lower thrips populations compared to those who do not. Farmers' adaptations to the thrips population surge include increasing the frequency and dosage of pesticide sprays, harvesting crops earlier, and abandoning infested fields, often leading to crop failure. Identification results confirmed that the thrips infesting shallots in Brebes and Tegal are *T. tabaci*.

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