PLANT SCIENCE TODAY
Vol 13(1): 1-6
https://doi.org/10.14719/pst.10751

eISSN 2348-1900

RESEARCH ARTICLE

Life cycle and host-dependent rearing efficiency of *Thrips tabaci* Lindeman on onion and runner bean

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Received: 19 July 2025; Accepted: 25 September 2025; Available online: Version 1.0: 26 December 2025; Version 2.0: 08 January 2026

Cite this article: Aravinthraju K, Shanthi M, Murugan M, Manikanda Boopathi N, Anandham R, Srinivasan R, Lourena AM. Life cycle and host-dependent rearing efficiency of *Thrips tabaci* on onion and runner bean. Plant Science Today. 2026; 13(1): 1-6. https://doi.org/10.14719/pst.10751

Abstract

Onions are the second most widely produced vegetable globally, after tomatoes and are vulnerable to both biotic and abiotic stresses. Among the key pests, *Thrips tabaci* Lindeman is a polyphagous species that poses a major threat to onion production, causing direct damage and acting as a vector for tospoviruses. This study used ITS2-based PCR and Sanger sequencing to molecularly confirm the identity of field-collected *T. tabaci*, showing 100 % identity with reference *T. tabaci* sequences. The life cycle of *T. tabaci* was evaluated under controlled conditions on onion (*Allium cepa* L.) and runner bean (*Phaseolus coccineus* L.). Developmental parameters including egg, nymphal, pupal stages and adult longevity, were recorded on both hosts. Development was significantly faster on runner bean leaves (29.33 ± 5.58 days), while adult longevity was greater on onion leaves (20.07 ± 5.10 days). Mass rearing trials on single-host systems showed that onion leaves supported a higher multiplication fold (4.34 ± 0.63) compared with bean leaves (2.75 ± 0.50) when 100 adults were released. This indicates that the onion is more suitable for oviposition and overall colony buildup than the runner bean under controlled conditions. These findings show how the life cycle of *T. tabaci* can be regulated by its host. Collectively, onion favoured oviposition and overall colony build-up, while runner bean accelerated immature development-complementary traits that can be leveraged for laboratory culture and bioassay logistics.

Keywords: insect–host interaction; longevity; mass rearing; onion; runner bean; thrips

Introduction

Onions are the second most widely produced vegetable (111 million tons) globally, after tomatoes (192 million tons) (1). Onion production is being affected by various biotic and abiotic stresses, including pests and diseases. One of the major pests of onion is *Thrips tabaci* Lindeman (Thysanoptera: Thripidae), commonly known as onion thrips, an economically significant polyphagous insect pest. It infests a wide range of vegetable and ornamental crops, particularly in the families Alliaceae, Solanaceae, Cucurbitaceae and Fabaceae (2). Onion, garlic and other allium crops are their primary hosts, where they cause significant direct feeding damage and transmit tospoviruses, including Iris yellow spot virus (IYSV) and Tomato spotted wilt virus (TSWV) (3, 4). It causes a 26 %–57 % yield loss in onions (5). In recent years, *T. tabaci* has emerged as a major constraint in onion cultivation across Asia and other regions due to its increasing resistance to insecticides, cryptic diversity and environmental adaptability (2, 6).

The life cycle of *T. tabaci* consists of eggs, two larval instars, two non-feeding pupa like stages (prepupa and pupa) and adults. Unlike holometabolous insects, thrips undergo simple metamorphosis (with egg, larvae and pseudo-pupa and adult stages) with all active stages capable of infesting host tissues (7). Its ability to reproduce parthenogenetically adds to its pest status and population build-up potential (8). The developmental duration, fecundity and survival of *T. tabaci* vary considerably depending on the host plants and environmental conditions (9). Thus, understanding its biology on different host plants is critical to developing efficient mass rearing techniques for experiments.

Previous studies have indicated that host plant species influence various biological parameters of *T. tabaci*, including development rate, adult longevity, fecundity and virus transmission efficiency (10). For instance, while onion and garlic support adult survival and oviposition (11), broad-leaved plants like legumes and cucurbits promote faster development due to higher tissue palatability and nutritional quality (12). Several researchers have exploited these host preferences in designing mass rearing protocols under laboratory and semi-field conditions (7, 13). However, limited studies have compared *T. tabaci* biology in dual-host systems, particularly in combinations of onion and leguminous crops, such as

runner bean (*Phaseolus coccineus* L.), which are known to support rapid nymphal development and ease the recovery and observation of immature stages.

Accurate species identification is another key aspect, as *T. tabaci* comprises several cryptic lineages with different ecological preferences and virus vector competencies. Traditional morphology -based identification often fails to distinguish these lineages due to their high phenotypic plasticity and overlapping characters (14). Therefore, molecular methods, especially Polymerase Chain Reaction (PCR)-based identification using the Internal Transcribed Spacer (ITS) region, have been increasingly adopted to confirm the identity of *T. tabaci* populations (15, 16). The ITS2 region has proven effective in differentiating among *T. tabaci* lineages and is routinely used in DNA barcoding and phylogenetic studies (17).

While earlier research has explored the biology and rearing of *T. tabaci* on individual hosts such as onion, garlic, cucurbits and beans, a thorough assessment of dual-host systems has yet to be conducted (10). Specifically, the combination of onion and runner bean has not been studied, despite having a clear biological foundation: onion is favoured for oviposition but promotes slower immature development, while runner bean leaves facilitate quicker nymphal growth and easier handling (12). Prior mass-rearing methods mostly relied on single hosts, which often restricted colony growth and increased the labour required to manage various life stages. By systematically testing the alternation between onion and runner beans as hosts, this research addresses a methodological gap and introduces an innovative rearing technique that leverages the complementary benefits of both host plants, resulting in enhanced colony growth, improved handling efficiency and greater reliability for experimental purposes.

The current study was conducted to collect, identify and evaluate the biological performance of *T. tabaci* on two commonly available host plants–onion (*Allium cepa* L.) and runner bean (*Phaseolus coccineus* L.) under controlled conditions. The objectives were: (i) to confirm the identity of the collected *T. tabaci* population using ITS2 primers; (ii) to determine stage-wise duration and total life cycle of *T. tabaci* on both hosts and (iii) to assess different combinations of oviposition and feeding substrates for maximizing multiplication ratio under laboratory rearing. This dual-host approach aims to enhance the efficiency of colony maintenance and handling of immature stages for downstream applications including bioassays, molecular analyses and Integrated Pest Management (IPM) research. The outcomes also provide insights into host-mediated variations in *T. tabaci* biology, which is essential for pest forecasting and aids the development of resistant cultivars in onions and related crops. This approach integrates host biology with practical implications for mass rearing protocols, an area with limited experimental optimization.

Materials and Methods

Collection and molecular confirmation of *Thrips tabaci*

The test insect *Thrips tabaci* Lindeman was collected from onion fields at the World Vegetable Center in Taiwan. Both nymphal and adult stages were directly collected from infested onion plants in the field. The insect species were morphologically confirmed using taxonomic keys. Genomic DNA from *T. tabaci* was extracted from 10 adult insects by using the DNeasy Blood and Tissue Kit (Qiagen) according to the manufacturer's protocol. Species confirmation for *T. tabaci* was done using the primers ITS2_F (Forward) CGACTTTCGAACGCATATTGC and ITS2_R (Reverse) GCTTAAATTCAGGGGGTAATCTCG, which amplify a partial region of the Internal Transcribed Spacer (ITS) gene (17). PCR was carried out in a 25 µl reaction volume containing 12.5 µl of 2X Master Mix RED, 1 µl of each primer (10 pmol/µl), 9 µl of nuclease-free water and 1.5 µl of template DNA (100ng/µl). PCR was performed using a thermal cycler (VertiPro, Thermoscientific, USA) with an initial denaturation at 95 °C for 10 min, followed by 35 cycles of denaturation at 95 °C for 30 sec, annealing at 53 °C for 30 sec and extension at 72 °C for 30 sec, with a final extension at 72 °C for 10 min. Amplified PCR products were separated on a 1 % agarose gel and visualized under UV light. The expected amplicons were purified and sequenced bi-directionally by Sanger sequencing (Genomics Bioscience and Technology Co., Ltd., Taiwan). Sequences were aligned and compared with NCBI BLAST to confirm species identity.

Host plants and rearing conditions

To evaluate biological performance and optimize rearing, *T. tabaci* was cultured under laboratory conditions, separately with onion (*Allium cepa* L.) and runner bean (*Phaseolus coccineus* L.) leaves (Fig. 1). Freshly cut young onion and bean leaves (grown under controlled conditions) were included in the culture. The leaves were wrapped with wet cotton around the stalks to ensure oviposition (on young leaves) and feeding (on older leaves). Fresh leaves are replaced every

Bean leaves

Onion leaves

Fig. 1. Growing plants under sterilized conditions.

five days to provide a nutritious food source for the thrips. The rearing condition was maintained inside the growth chamber at 25 ± 1 °C, 70 ± 10 % Relative Humidity (RH) and a 14 hr light/10 hr dark photoperiod.

Life cycle observation on onion and runner bean

To assess developmental parameters, 10 individual *T. tabaci* insects (male and female combined) were monitored per host plant, with three replications. Observations included the duration of egg, nymphal instars, pupal stages (prepupa and pupa) and adult longevity. Data were recorded daily from oviposition day till the adult death of all individuals (Table 1).

Mass rearing trials and multiplication ratio assessment

To determine host suitability for multiplication, 100 newly emerged adult *T. tabaci* were released into rearing boxes containing either onion or bean leaves. The released adult thrips were allowed to oviposit for 2 days before being collected. The container was maintained until the emergence of F_1 adults.

Statistical analysis

The life history parameters recorded were summarized as mean ± standard deviation (SD) based on replicates (n = 10 individuals). To evaluate host suitability, the data across the feeding conditions were analyzed using one-way Analysis of Variance (ANOVA), where data normality and homogeneity were tested for grouping. Least Significant Difference (LSD) test was used for *post hoc* multiple comparisons at a 5 % significance level ($p < 0.05$) to identify statistically significant groupings among treatments. All statistical analyses were performed using the software SPSS version 22.

Results

Molecular confirmation of *Thrips tabaci* Lindeman

The *T. tabaci* population was collected from the field during the late winter season (March 2024) at World Vegetable Center, Taiwan. This is the onion-growing season in Taiwan, where the incidence of this species is reported more frequently. The PCR amplification of genomic DNA from the ITS region produced a distinct single band of the expected size (~650 bp) on a 1 % agarose gel, indicating successful amplification (Fig. 2). The amplified ITS fragments were sequenced bi-directionally using the Sanger method. Analysis of the resulting sequences was performed using NCBI BLAST, which revealed a 100 % match with *T. tabaci* sequences available in the GenBank database (Accession number: AB904209). This confirmed species identity at the molecular level.

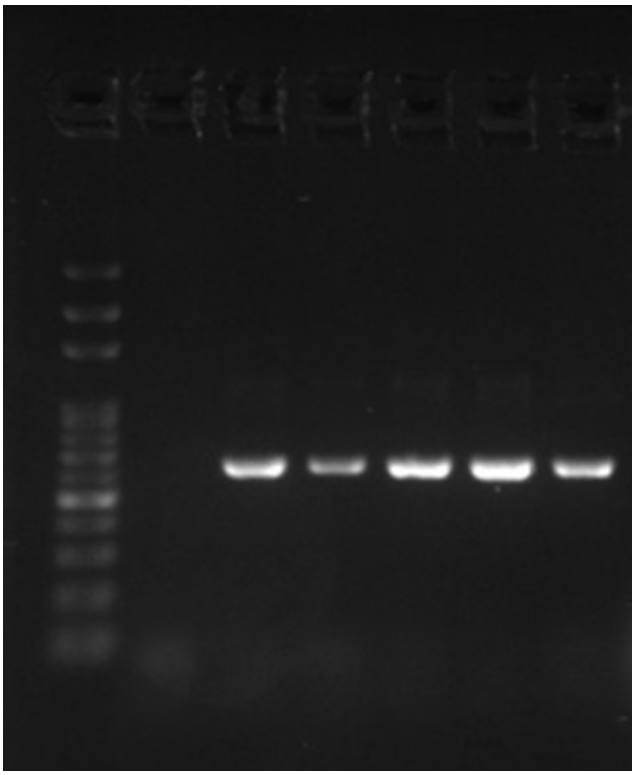

Fig. 2. GEL image for molecular confirmation of *T. tabaci* (Sample 1 - 5).

Life cycle of *Thrips tabaci* on runner bean and onion hosts

The development period of *T. tabaci* differed significantly between runner bean and onion leaves (Table 1). The egg period was longer on runner bean leaves (4.87 ± 0.79 days) compared to onion leaves (4.57 ± 0.62 days). The first instar nymph period was shorter on runner bean leaves (2.23 ± 0.43 days) than on onion leaves (2.73 ± 0.84 days). The second instar nymph had a shorter developmental period on runner bean leaves (4.53 ± 0.52 days) compared to onion leaves (5.97 ± 1.04 days). The pre-pupal period was consistent across both hosts (1.87 - 1.90 ± 0.88 days). However, the pupal period was shorter on runner bean leaves (2.30 ± 0.48 days) than on onion leaves (3.30 ± 0.48 days). Adult longevity was more on onion leaves, averaging 20.07 ± 5.10 days, whereas adult life was only 13.50 ± 4.98 days on runner bean leaves. Consequently, the total life cycle of *T. tabaci* was shorter on runner bean leaves (29.33 ± 5.58 days) compared to onion leaves (38.53 ± 5.36 days). While development was faster on bean leaves, onion leaves supported longer adult

Table 1. Biology of *Thrips tabaci* in runner beans and onion hosts

Life stages		Duration in runner beans (Days)*	Duration in onion (Days)*
Egg period		4.87 ± 0.79	4.57 ± 0.62
Nymphal period	**I instar**	2.23 ± 0.43	2.73 ± 0.84
	II instar	4.53 ± 0.52	5.97 ± 1.04
Pre-pupal period		1.87 ± 0.88	1.90 ± 0.88
Pupal period		2.30 ± 0.48	3.30 ± 0.48
Adult longevity		13.50 ± 4.98	20.07 ± 5.10
Total life cycle		29.33 ± 5.58	38.53 ± 5.36

*Each value is the mean + Sd (n = 30)

Mean followed by standard deviation.

Table 2. Multiplication of *Thrips tabaci* in two hosts

Feed combination	Adult released	F1 generation adults*
Bean leaves	100	275.00 ± 50.58[b]
Onion leaves	100	434.66 ± 63.10[a]

*Means ± SD (n = 10) in a column followed by different letters differ significantly by LSD ($p < 0.05$).

longevity, suggesting a trade-off between development speed and adult survival.

Host-dependent multiplication ratio of *Thrips tabaci*

Host plants had a significant effect on the multiplication ratio of *T. tabaci* (Table 2). The mean adults were higher on onion leaves (434.66 ± 63.10) than on bean leaves (275 ± 50.58) ($p < 0.05$). These results indicate that onion leaves provide a more favorable substrate for oviposition and adult survival, whereas bean leaves, although supporting development, resulted in lower population buildup.

Discussion

Insect mass rearing is a fundamental requirement for ecological, behavioral and toxicological research (18), particularly when working with species such as *Thrips tabaci* Lindeman which are utilized in studies on virus transmission, insecticide bioassays and endophytic colonization (19). However, successful rearing demands the selection of appropriate host materials that maximize fecundity and minimize labor for insect recovery and maintenance. The suitability of different host plants for *T. tabaci* multiplication has been previously tested in mono-host systems; however, evaluating combinations of oviposition and feeding substrates could significantly improve rearing efficiency (20). Confirming the species identity is a crucial first step, particularly in cryptic complexes such as *T. tabaci.* The present study confirms the identity of *T. tabaci* using both morphological and molecular approaches. It investigates its developmental biology and mass rearing potential on two host plants–onion (*Allium cepa* L.) and runner bean (*Phaseolus coccineus* L.). The ITS2-based molecular confirmation yielded a 100 % identity match with known *T. tabaci* sequences, validating the identification method employed in prior entomological and molecular studies (17).

The comparative life history traits of *T. tabaci* on onion and runner bean indicate significant host-dependent variation in developmental parameters. Such variations have been widely reported in host-adapted lineages or cryptic species of *T. tabaci*, where both ecological specialization and genetic differences influence life cycle durations (21). In the current study, *T. tabaci* developed faster on runner bean leaves than on onion, particularly during the nymphal stages. This finding aligns with earlier research, which suggests that legumes, such as beans, often promote rapid larval development due to their softer leaf tissues and favorable nutritional profile (9). However, adult longevity was markedly higher on onion leaves, indicating that while bean leaves may facilitate quick immature development, onion leaves are more suitable for prolonged adult survival and sustained reproduction. These results are consistent with the concept of host alternation, where different plants may favour specific life stages of polyphagous insects (22). Developmental variations are likely influenced by the chemistry and structure of the host. Leaves of runner beans generally provide greater nitrogen/protein content, as well as a softer texture, which facilitates quicker nymph growth and shorter instars. Conversely, onion leaves possess dense epicuticular wax and sulfur-associated phenolics that hinder feeding, extend developmental time and alter the trade-offs between survival and reproduction. Notably, the reduction of onion leaf wax (in glossy mutants) heightens susceptibility to thrips while downregulating genes responsible for wax biosynthesis, demonstrating a direct mechanical and chemical barrier to herbivory that aligns with the current staged findings. These host characteristics likely account for the more rapid immature development observed on beans and the prolonged adult survival seen on onion in this study (23).

The total life cycle duration on onion leaves (38.53 ± 5.36 days) was longer compared to runner bean leaves (29.33 ± 5.58 days), yet onion leaves supported higher adult survival. This suggests a trade-off between faster development and adult longevity, which could be a critical consideration in designing laboratory rearing protocols or pest forecasting models (24).

In terms of mass rearing, single-host trials revealed that onion leaves supported a significantly higher multiplication fold. This confirms that onion is a more suitable substrate for oviposition and adult survival, while bean leaves provide less favorable conditions for sustained population growth. The observed difference is likely due to the higher nutritional content and lower wax layer of onion leaves, which enhance fecundity and survival. Nevertheless, bean leaves can still be useful for short-term maintenance or for observing immature stages due to their broad lamina and ease of handling.

The present findings also highlight the handling advantages of bean leaves during nymphal stages due to their broader lamina and lower waxy cuticles, which improve recovery and enumeration of nymphs. This is crucial for experimental bioassays and developmental studies, as leaf morphology has a profound influence on insect behaviour and observability (27). From a pest management perspective, understanding host-dependent variation in life history traits provides a foundation for integrated control strategies. For example, crops that slow down the thrips development or reduce fecundity can be selected in breeding programs for resistance (28, 29). In contrast, highly suitable hosts like bean should be carefully monitored or excluded from intercropping systems where *T. tabaci* is a key pest.

The molecular confirmation using ITS2 further supports its application in distinguishing cryptic lineages and monitoring genetic variability in *T. tabaci* populations, which is increasingly vital under climate change and global trade dynamics (17). This is critical not only for colony maintenance but also for monitoring population structure and resistance development under field conditions.

Conclusion

The study provides valuable insights into the biology and rearing performance of *T. tabaci* on onion and bean hosts. Onion leaves supported greater multiplication and longer adult longevity, confirming their suitability as the primary host for laboratory colony maintenance. Runner bean leaves, though less effective for multiplication, can facilitate handling of immature stages. These findings aid in optimizing rearing protocols and designing pest management and biological studies on *T. tabaci*.

Funding

This work was funded under the Vegetable Innovation Projects (VIP3) by the Ministry of Agriculture, Taiwan, project number 114-A. S-1.2.3-S-02 (2) and long-term strategic donors to the World Vegetable Center: Taiwan, UK aid from the UK government, United States Agency for International Development (USAID), Australian Centre for International Agricultural Research (ACIAR), Germany, Thailand, Philippines, Korea and Japan.

Acknowledgements

The authors also acknowledge the long-term strategic donors to the World Vegetable Center, including Taiwan, the United States, Australia, the United Kingdom, Germany, Thailand, South Korea, the Philippines and Japan.

Authors' contributions

AK conceptualized the study and prepared the original draft; SR and LAM provided resources; SM, MM, MBN, AR, SR and LAM contributed to review and editing; and SR and LAM supervised the work. All authors read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest: The authors declare that they have no conflicts of interest.

Ethical issues: None

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work, the authors utilised ChatGPT to refine the language. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

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Peer review: Publisher thanks Sectional Editor and the other anonymous reviewers for their contribution to the peer review of this work.

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