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Full-text article

THE USE OF INTEGRATED METHODS FOR CONTROLLING THE TOBACCO THRIPS *THRIPS TABACI* ON EGGPLANT UNDER GREENHOUSE CONDITIONS

D. Undarmaa[1]*, A. Siiriimaa[2], Z. Altantsetseg[1,3]

[1] *School of Agroecology, Mongolian University of Life Sciences, Zaisan, Ulaanbaatar, Mongolia*
[2]*Plant Protection Institute, Zaisan, Ulaanbaatar, Mongolia*
[3]*University of Food industry and Technology, Ulaanbaatar, Mongolia*

**corresponding author, e-mail: undarmaa@muls.edu.mn*

The tobacco thrips *Thrips tabaci* is a prevalent insect-pest found worldwide, extensively distributed in greenhouses of Mongolia. This study aimed to evaluate the effectiveness of predatory mites and botanical pesticides in controlling tobacco thrips populations in eggplant crops. An experiment was conducted in a 120 m² greenhouse at the “Agropark” Experimental Research Center of the Mongolian University of Life Sciences. Four treatments were applied to infested eggplant plots: a) the predatory mite *Amblyseius swirskii*, b) *A. swirskii* combined with Neem oil; c) Neem oil alone; and d) Neem oil combined with bio-stimulant BEB containing extract of the fungus *Ganoderma lucidum*. The average mortality rates of tobacco thrips across three years ranged from 45% to 93% due to *A. swirski*, 77% to 97% due to *A. swirskii* plus Neem oil, 75% to 96% due to Neem oil; and 77% to 96% due to Neem oil plus BEB. All treatments demonstrated promising results in significantly reducing thrips populations under greenhouse conditions. However, to ensure the effectiveness of biological control, it is important to release predatory mites at least five days after the application of botanical insecticides, such as Neem oil. Based on the findings, we recommend the use of *Amblyseius swirskii*, either alone or in combination with botanical products, as a safe and effective plant protection measure for controlling tobacco thrips in greenhouse-grown eggplants.

Keywords: integrated pest control, predatory mite, *Amblyseius swirskii,* botanical insecticide, plant growth regulator

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Introduction

The tobacco thrips *Thrips tabaci* Lindeman (Fig. 1A), commonly known as the onion thrips or tobacco thrips, belongs to the class Insecta, order Thysanoptera, family Thripidae (Mehle, 2012). It is a tiny, slender insect of a significant agricultural threat due to its direct feeding damage, ability to transmit plant viruses, and rapid development of insecticide resistance (Riley, 2011). This harmful arthropod is widespread in many countries around the world (Loredo, 2022), where it infests various plants, including onions, garlic, tobacco, cotton, and ornamental plants (Lewis, 1997), and causes damage in non-agricultural areas, such as forested regions and natural habitats, as well as cultivated fields (Chuluunjav et al., 2015).

In Mongolia, while tobacco thrips was first reported on vegetable fields by Tsendsuren et al. (1979), systematic studies on Thripidae taxonomy remained lacking (Chogsomjav, Shuravenkov, 1965). The integrated morphological and molecular analysis identified collected specimens as *T. tabaci*, showing complete genetic congruence with Chinese populations (Genbank accession # MN036455) (Yan Lan Xie, 2022). This confirmation led to our NCBI GenBank submission (#OP288232), establishing the first molecular record of this pest in Mongolia (Altantsetseg, Undarmaa, 2023).

Management of *T. tabaci* remains challenging due to its high reproductive rate, cryptic behavior, and resistance to multiple chemical insecticides. Integrated pest management (IPM) strategies, including biological control, cultural practices, and selective insecticide use, are essential for sustainable control (Mound, Kibby, 1998). The primary strategy for controlling the tobacco thrips has long relied on synthetic insecticides, including organophosphates (e.g., chlorpyrifos), pyrethroids (e.g., lambda-cyhalothrin), and neonicotinoids (e.g., imidacloprid) (Benelli et al., 2016; Campos et al., 2016). However, the intensive use of these chemicals has led to several negative consequences: *T. tabaci* has developed resistance to multiple chemical classes due to its short life cycle, high reproductive rate, and overexposure to insecticides. Resistance to spinosad, abamectin, and pyrethroids has been widely documented, reducing the efficacy of chemical control (MacIntyre Allen, 2005). Given these challenges, IPM approaches are essential for sustainable *T.tabaci* control (Undarmaa et al., 2015), including the use of biological control agents, such as predatory mites and entomopathogenic fungi (Riudavets, 1995).

Biological methods, when applied appropriately, offer a safer and more environmentally friendly alternative. Therefore, this study explores the use of biological methods and the potential benefits they offer in terms of both effectiveness and environmental impact (Yaşarakıncı et al., 2000). Another potential pest treatment is the synergistic effect of Neem oil with beneficial arthropods in an IPM program. Neem oil contains at least 100 biologically active compounds. Among them, the major components are triterpenes known as limonoids, the most important being azadirachtin, which is responsible for about 90% of the effects on most pests (Campos et al., 2016).

The several challenges was found in using Neem oil for pest control. The findings of Feng and Isman (1995) highlighted that repeated exposure to pure azadirachtin led to significant resistance (9-fold) in *Myzus persicae* after 40 generations, whereas resistance did not develop in peach aphids treated with a multi-component Neem seed extract, underscoring the potential of botanical blends with diverse bioactive compounds to delay resistance evolution compared to single-active ingredient insecticides (Feng, Ishman, 1995). Moreover, there are significant risks due to its low residual power; multiple applications are required, which can increase selection pressure on pest populations and potentially lead to resistance.

The objective of this study is to test a treatment for mitigating tobacco thrips infestations, with a particular focus on meeting organic cultivation requirements. Within the scope of this study, our goal was to investigate and assess the effectiveness of biological control agents by applying predatory mites and botanical pesticides on eggplants inhabited by the tobacco thrips population in the greenhouse.

The objective of this study is to test a treatment for mitigating tobacco thrips infestations, with a particular focus on meeting organic cultivation requirements.

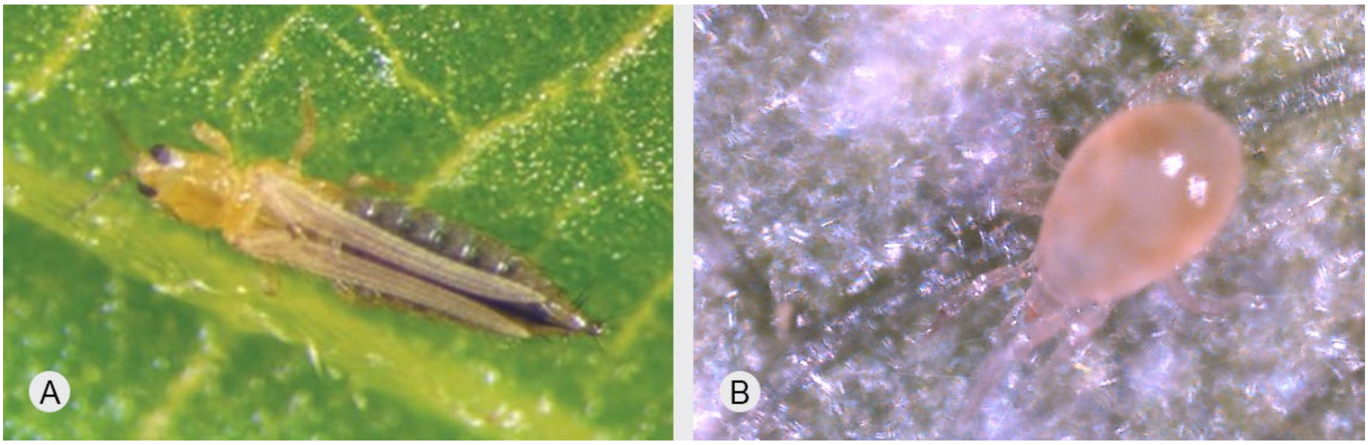


Figure 1. Tobacco thrips *Thrips tabaci* (A) and predatory mite *Amblyseius swirskii* (B)

Рисунок 1. Табачный трипс *Thrips tabaci* (A) и хищный клещ *Amblyseius swirskii* (B)

Materials and Methods

Location of experimental plot

The study was conducted in the eggplant greenhouse with a size of 120 m^2 at the "Agropark" (47.879458° N latitude, 106.914666° E longitude) field experimental research center of the Mongolian University of Life Sciences during the plant growth seasons in 2017–2019. This center is situated in the Zaisan Valley in the Khan-Uul District of Ulaanbaatar, the capital of Mongolia. The territory of Mongolia lies within the middle latitudes of Central Asia, in the Northern Hemisphere. According to the world's soil and climate classifications, Mongolia exhibits a cool climate in terms of heat resources and falls under the category of a dry and arid region with regards to humidity. It is situated in a region characterized by a continental climate, covering an area of 1,569.9 thousand km^2, with elevations reaching 1,380 meters above sea level. The study was conducted in the Zaisan Valley, which is a part of Bogdkhan Mountain, a subrange of the Khentii Mountains. In terms of climate characterization, the Zaisan Valley locates within the humid and temperate sub-region of Mongolia's central agricultural region. (Jambaajamts, 1983). Annual rainfall ranges from 250 to 270 mm. The cumulative heat units during the plant growth period range from 1500 to 2200 °C degree-days, and the plant growth period lasts for 90 to 100 days. The soil exhibits a light mechanical composition with a high water absorption capacity, predominantly consisting of dark brown, brown, and light brown soils. The cultivated area is situated at an elevation of 800 to 1100 meters above sea level (Jambaajamts, 1983).

The greenhouse used in our experiment, made of plastic material, was not equipped with any systems to regulate temperature or humidity. Therefore, its internal climate closely reflected the external conditions. Air temperature and relative humidity were measured every 10 days at midday from May to September, continuing until the end of the harvest period. In Mongolia, the climate is characterized by large temperature differences between day and night, even during the summer.

Based on the greenhouse's three-year average temperature and humidity data during the plant growth period—particularly from May to August, which is critical for plant development—the 10-day averages were as follows: temperature ranged from 21.1 °C to 24.9 °C, and relative humidity ranged from 36.1 % to 71.3 % (Fig. 2).

The soil at the location where the greenhouse was placed was used in this experiment; no artificial or imported soil was exploited.

Research materials

In these experiments, we utilized the predatory mite *Amblyseius swirskii* (Athias-Henriot) (Fig. 1B), purchased from the Koppert company in the Netherlands. It was reared in the laboratory for research purposes since 2015. Additionally, we imported the botanical pesticide, the neem oil, from the USA and obtained a natural plant growth regulator, BEB, from China, which reduces plant stress and promotes its growth. Neem oil is a natural pesticide derived from the seeds of the Neem tree *Azadirachta indica* Juss (Meliaceae). It is widely used in agriculture and horticulture for its effectiveness against a variety of pests and diseases. The primary active ingredient in Neem oil is azadirachtin, which disrupts insect feeding and reproduction (Benelli at al. 2016). BEB is the trade abbreviation for the Plant Cell Energy Factor, developed by

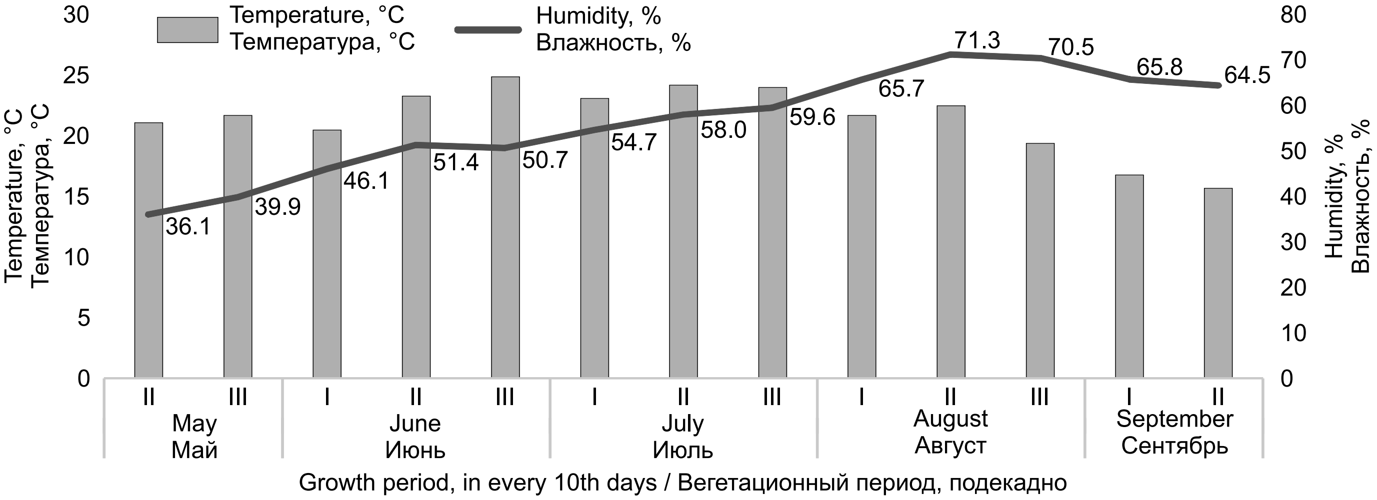


Figure 2. Mean temperature and humidity values during the growth period in the greenhouse during three years of study

Рисунок 2. Средние значения температуры и влажности вегетационного периода в теплице в течение трёх лет исследования

Langfang Weijin Agricultural Technology Co., Ltd. (Langfang Weijin ..., 2025). It is formulated from ingredients such as red chaga mushroom *Ganoderma lucidum*, oyster shell, and corn, designed to support plant recovery and enhance pest resistance.

Experimental design

Between 2017 and 2019, following the onset of tobacco thrips infestation in the greenhouse eggplant plot, research was conducted to evaluate four treatments against the pest and an untreated control, each with four replications. The experiment for controlling tobacco thrips was tested in 20 plots, each with a size of 6 sqm, and in each plot, 24 plants were grown. In total, 480 plants were used for the experiment, with each plot being replicated four times. The experimental layouts were arranged in a Completely Randomized design (CR), with each plot positioned 60 cm apart and separated by a mesh curtain. Subsequently, we randomly allocated the five treatments including untreated control to the plots in each row, so that there is one replicate per row.

The following treatments were applied: variant A: the predatory mite *A. swirskii* at 1:5 ratio (predator:pest); variant B: *A. swirskii* 11:5 +Neem oil (30 ml/4.5 liters of water); variant C: Neem oil; variant D: Neem oil + BEB (20 ml/10 liters of water); variant E: untreated control. For variant B, Neem oil treatment was followed by predatory mite application five days later.

Data collection and analysis

The results of these biological control treatments were determined by assessing the percentage of thrips mortality. The assessment involved counting the number of surviving insects before the treatment and at intervals of 24 hours, 5-, 10-, 15-, and 20-days post treatment on marked plants, using a digital magnifier with 200x–1000x magnification. The number of survived thrips per 25 leaves was counted on marked plants per plot (total 100 leaves per treatment).

The weight and number of commercially mature fruits per plant were recorded from a 1 m² area of each variant at harvest time, and the total yield of each plot was calculated separately. The usable yield was determined by counting and weighing each fruit over a period of 3–5 days during the ripening stage.

Data analysis for effect of treatments was conducted using Excel Data Analysis and One way ANOVA with the Student-Newman-Keuls (Sigmaplot.15 version). To perform polynomial trend analysis in Excel, we fit our data into a polynomial regression equation. The general form of a second-degree (quadratic) polynomial trendline is:

$$y = ax^2 + bx + c$$

Where: y is the number of individuals (dependent variable), x is the time after treatment (independent variable, e.g., 0, 1, 5, 10 for days), a,b,c are determined by regression coefficients.

The effectiveness of treatments was calculated using Henderson-Tilton's formula (1955), which involves the following formula:

$$Efficacy\ (\%) = 1 - \frac{nCo,\ before \times nT,\ after}{nCo,\ after \times nT,\ before} \times 100$$

Where: n = Insect population, T = treated, Co = control

Statistical analysis of total plot yield and 1 m² area yield was conducted using SigmaPlot 15 software, applying the Student-Newman-Keuls method of one-way ANOVA followed by All Pairwise Multiple Comparison Procedures (Tukey Test) and Anova Repeated Measurement test.

Results

A greenhouse experiment resulted on eggplant for a control of tobacco thrips using the following treatments was evaluated. Mean mortality rates across three years (2017–2019) are shown in Table 1.

In terms of treatment effect, variant B demonstrated significantly greater effectiveness than the other treatments across all time points, particularly during the 5–15 days post-application period. In contrast, variant A exhibited significantly lower effectiveness during the initial phase; however, it maintained stable control thereafter. Variants C and D showed comparable efficacy, although neither surpassed variant B in overall performance.

Observations of thrips populations across treatment plots revealed distinct differences in pest suppression among the tested variants.In Treatment A, the thrips population followed a clear polynomial decline ($R^2 = 0.99$; Figure 3) relative to pre-treatment levels. The average number of pests per 100 leaves decreased from 448.7 before application to 291.0 within 24 hours, continuing to drop sharply thereafter. The population later stabilized, indicating that A. swirskii effectively suppressed and maintained control of the thrips population (Figure 3A).

Treatment B, which combined *A. swirskii* with Neem oil, achieved the most rapid and sustained suppression among all variants. This integrated approach provided the highest control efficiency and demonstrated a synergistic interaction

Table 1. Effect of treatment used for controlling tobacco thrips in eggplant plantings

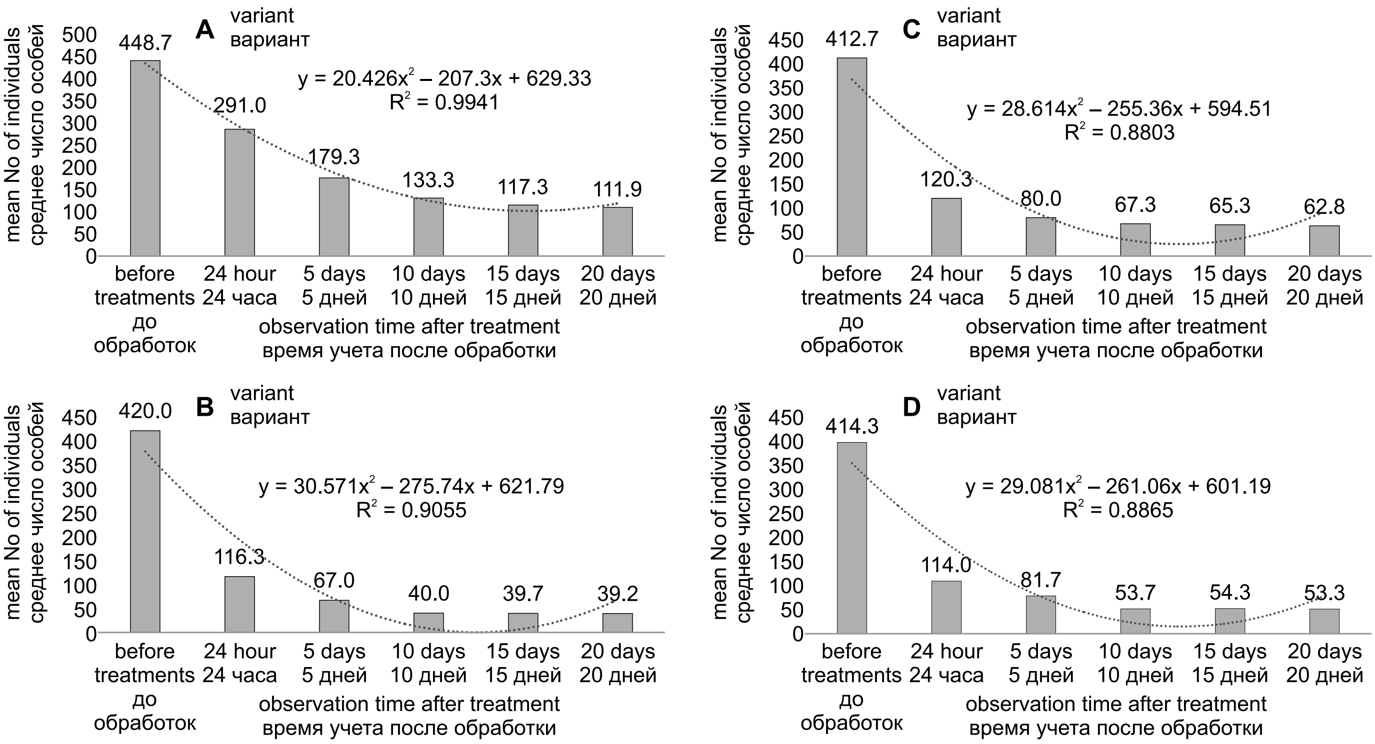
Variants	Mortality rate (%±SE) in average 2017–2019				
	24h	5 days	10 days	15 days	20 days
A (*A. swirskii*)	*44.98±24.1	75.95±0.9	*87.92±2.7	*91.67±1.7	*92.72±5.0
B (*A. swirskii* + Neem oil)	76.51±5.5	90.40±2.1	96.13±0.6	96.99±1.1	97.28±0.2
C (Neem oil)	75.27±4.7	88.34±3.6	93.36±1.5	94.96±0.3	95.56±1.2
D (Neem oil + BEB)	76.66±1.5	88.13±2.0	94.73±1.8	95.83±1.3	96.25±1.5

Remark: * indicates a significant difference between 24h group and the 10-, 15-, and 20-day groups within A treatment according to Anova RM analysis.

Таблица 1. Эффект обработки против табачного трипса в посадках баклажана

Варианты	Смертность (%±SE), усредненная за 2017–2019 гг.				
	24 часа	5 дней	10 дней	15 дней	20 дней
A (*A. swirskii*)	*44.98±24.1	75.95±0.9	*87.92±2.7	*91.67±1.7	*92.72±5.0
B (*A. swirskii* + масло ним)	76.51±5.5	90.40±2.1	96.13±0.6	96.99±1.1	97.28±0.2
C (масло ним)	75.27±4.7	88.34±3.6	93.36±1.5	94.96±0.3	95.56±1.2
D (масло ним + BEB)	76.66±1.5	88.13±2.0	94.73±1.8	95.83±1.3	96.25±1.5

Примечание: * обозначает существенное раличие между эффектом через 24 часа и через 10, 15, 20 дней для варианта обработки А по результатам дисперсионного анализа.



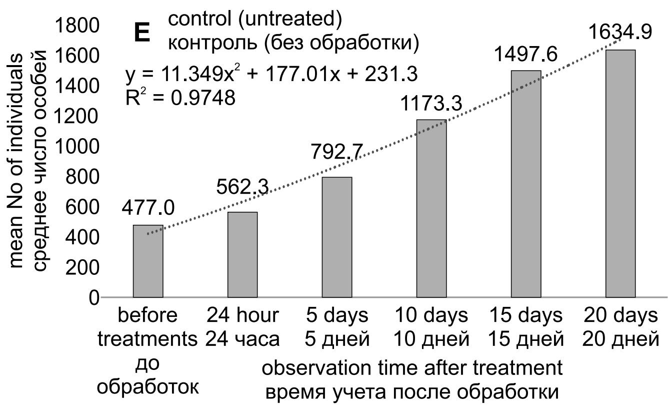


Figure 3. Dynamics of mean *Thrips tabaci* counts in eggplant planting at 1, 5, 10, 15, and 20 days after treatment, following a polynomial decline trend. A – predatory mite *Amblyseius swirskii*; B – *A. swirskii* + Neem oil; C – Neem oil; D – Neem oil + plant growth regulator BEB; E – untreated control

Рисунок 3. Динамика среднего количества *Thrips tabaci* в посадках баклажана на 1, 5, 10, 15, и 20 день после обработки, проявляющая полиномиальный тренд снижения. A – хищный клещ *Amblyseius swirskii*; B – *A. swirskii* + масло ним; C – масло ним; D – масло ним + регулятор роста растений BEB; E – необработанный контроль between the biological and botanical agents, highlighting the potential of integrated biological–botanical management under greenhouse conditions (Figure 3B). In Treatment C (Neem oil), a steady polynomial reduction in thrips density was observed (R^2 = 0.88; Figure 3C). Although the level of suppression was lower than that of the integrated approach in Treatment B, Neem oil alone maintained a moderate and consistent reduction throughout the experimental period. Treatment D combined Neem oil with the plant growth regulator BEB, producing significant polynomial suppression (R^2 = 0.98; Figure 3D) while simultaneously promoting plant vigor, suggesting complementary benefits between pest control and host recovery. An untreated control (Treatment E) was included for comparison. Unlike the treated plots, the control exhibited a continuous increase in thrips population (R^2 = 0.97; Figure 3E), confirming the pest's capacity for rapid proliferation under greenhouse conditions in the absence of intervention.

To assess treatment effects on crop productivity, total yield and yield per square meter were compared with the control. The integrated approach in Treatment B produced the highest yield gains, demonstrating that effective pest suppression directly enhanced crop performance. The average yield per plot (24 m²) of the different treatment variants was calculated over a three-year period. The results showed that the A variant yielded 26.6 kg/m², the B variant 31.0 kg/m², the C variant 28.0 kg/m², the D variant 25.0 kg/m², and the E (control) variant 22.6 kg/m². When calculating the average fruit yield per square meter, the A variant produced 4.4 kg/m², the B variant 5.2 kg/m², the C variant 4.7 kg/m², the D variant 4.2 kg/m², and the E variant 3.8 kg/m². When evaluating the effectiveness of the control methods based on the yield per 1 sqm, all treatment variants produced 0.4–1.4 kg/m² higher yields compared to the untreated control. This indicates the effectiveness of the applied control methods. The efficacy of the control methods was further evaluated based on yield data, analyzed using SigmaPlot 15 software. The total eggplant yield per treatment variant (A–E), averaged over three years (2017–2019) showed that variants B and C produced significantly higher yields than the untreated control (Fig. 4).

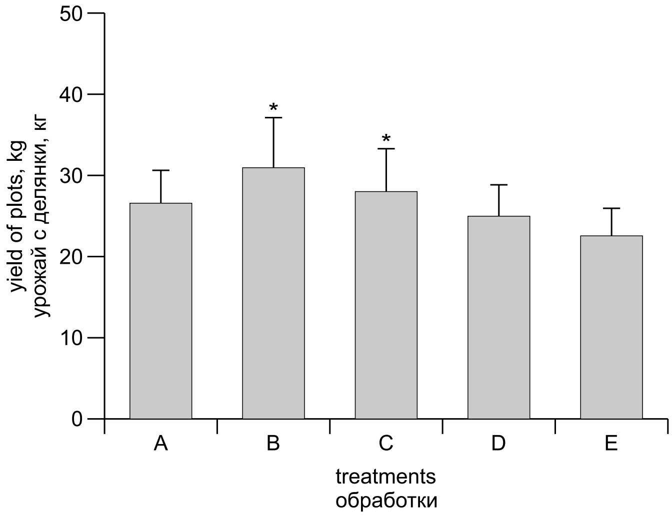


Figure 4. Total eggplant yield per treatment variant averaged over three years (2017–2019). Asterisks indicate significantly higher values compared to the untreated control (Tukey test, p ≤ 0.001). – predatory mite *Amblyseius swirskii*; B – *A. swirskii* + Neem oil; C – Neem oil; D – Neem oil + plant growth regulator BEB; E – untreated control

Рисунок 4. Суммарный урожай баклажана в среднем за три года (2017–2019). Звездочками отмечены значения, достоверно отличающиеся от необработанного контроля (Tukey test, p ≤ 0.001). A – хищный клещ *Amblyseius swirskii*; B – *A. swirskii* + масло ним; C – масло ним; D – масло ним + регулятор роста растений BEB; E – необработанный контроль

Discussion

In Mongolia, eggplants are cultivated exclusively under greenhouse conditions. Among greenhouse pests, tobacco thrips cause particularly severe damage to crops. Within the Thripidae family, research has shown that the Western flower thrips *Frankliniella occidentalis* Pergande and the tobacco thrips are the most destructive species in European greenhouses (Riudavets, 1995). In Mongolia, researchers first identified *T. tabaci* infestations in 1978–1980 (Chuluunjav, Undarmaa, 2015). Historically, chemical insecticides have been used to control the tobacco thrips in greenhouse crops. However, due to food safety concerns, IPM approaches with emphasis on biological control have been increasingly adopted worldwide (Waterhause,1989). Predatory mites from the *Phytoseiidae* and *Anthocoridae* families have shown particular promise (Wimmer, 2008). European studies by Wimmer et al. demonstrated that *A. swirskii* can effectively control first-instar larvae of both thrips species, achieving 67–78 % mortality. *Amblyseius swirskii* has proven to be a highly effective generalist predator for greenhouse pest management (Schausberger et al., 2018).

Notably, while combined use of *A. cucumeris* and *A. barkeri* against tobacco thrips showed limited efficacy due to interspecies competition, *A. cucumeris* alone demonstrated active predation and established populations for 9 weeks post-release (Mouden, 2017). In addition, *A. swirskii* effectively controlled the western flower thrips, *Frankliniella occidentalis* (Pergande), in the plots sprayed with pollen. Within 5 weeks after the introduction of the mite, the population density of *A. swirskii* reached up to three predatory mites (nymphs and adults) per leaf and they remained in high numbers on the leaves until the end of the study, even when the prey *F. occidentalis* was present in low numbers (Kutuk et al., 2011).

Our pioneering research in Mongolia evaluated *A. swirskii* (applied at 1:5 ratio) against tobacco thrips (*T. tabaci*) in greenhouse eggplants, achieving 86.3 % population reduction (Undarmaa et al., 2015). We further demonstrated that *A. swirskii* can be effectively combined with botanical pesticides (Neem oil), and staggered application (5-day interval between Neem and mite release) optimizes efficacy. Collectively, these results demonstrate that integrating the predatory mite *A. swirskii* with Neem oil provides the most consistent and durable yield benefits. Treatments combining biological and botanical components not only suppressed thrips populations effectively but also improved crop performance, underscoring the potential of integrated pest-management strategies to enhance both pest control and greenhouse crop productivity.

These findings validate that organic eggplant production in Mongolia is achievable through biologically-based

IPM strategies compliant with organic farming standards (Undarmaa et al., 2015). Growing research attention is focused on Neem, exploring the utility of its products as insecticides and antibiotics (Bielza, 2008; Benelli et al., 2016).

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Полнотекстовая статья

ИСПОЛЬЗОВАНИЕ ИНТЕГРИРОВАННЫХ МЕТОДОВ ДЛЯ БОРЬБЫ С ТАБАЧНЫМ ТРИПСОМ *THRIPS TABACI* НА БАКЛАЖАНЕ В УСЛОВИЯХ ЗАЩИЩЕННОГО ГРУНТА

Д. Ундармаа[1]*, А. Сийриймаа[2], З. Алтанцэцэг[1,3]

[1] Факультет Агроэкологий, Монгольский Университет Наук о Жизни, Зайсан, Улан-Батор, Монголия
[2] Институт защиты растений, Зайсан, Улан-Батор, Монголия
[3] Университет пищевой промышленности и технологий, Улан-Батор, Монголия

**ответственный за переписку, e-mail: undarmaa@muls.edu.mn*

Табачный трипс *Thrips tabaci* – сельскохозяйственный вредитель, широко распространённый во всем мире, в том числе в теплицах Монголии. Цель данного исследования заключалась в оценке эффективности хищных клещей и средств растительного происхождения в регулировании численности табачного трипса в посадках баклажана. Эксперимент проводился в теплице площадью 120 м² на базе исследовательского центра «Агропарк» Монгольского университета наук о жизни. Было испытано четыре варианта обработки заражённых участков баклажана: a) хищный клещ *Amblyseius swirskii*; b) *A. swirskii* в комбинации с маслом ним; c) масло ним; d) масло ним в сочетании с биостимулятором BEB (на основе экстракта гриба *Ganoderma lucidum*). Средние показатели смертности табачного трипса за три года варьировали от 45% до 93% при использовании *A. swirskii*, от 77% до 97% при сочетании *A. swirskii* и масла ним, от 75% до 96% при применении только масла ним и от 77% до 96% при сочетании масла ним с BEB. Все варианты показали высокую эффективность в виде значительном снижении численности трипсов в условиях теплицы. Для обеспечения эффективности биологического контроля важно выпускать хищных клещей не ранее, чем через пять дней после применения растительных препаратов, таких как масло нима. На основании полученных результатов рекомендуется использовать *A. swirskii* как самостоятельно, так и в комбинации с растительными препаратами в качестве безопасного и эффективного средства защиты растений от табачного трипса при выращивании баклажанов в тепличных условиях.

Ключевые слова: интегрированная защита растений, хищный клещ, *Amblyseius swirskii*, растительный инсектицид, регулятор роста растений

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