Moth development characteristics in tomato crop

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Abstract. In Uzbekistan, where the tomato holds a place of prominence among vegetable crops, the battle against pests, particularly moths, is of critical importance to ensure the delivery of high-quality tomato products to consumers. Through dedicated research, the distribution and dominant species of moths that inflict damage on tomato crops have been meticulously mapped out. This research has been pivotal in understanding the extent of damage these pests can cause at various stages of tomato growth, enabling targeted interventions. The damage caused by moths to tomato crops is not uniform and varies with the growth stages of the plant. Early infestations can severely impact seedling development, while later attacks can compromise the fruit's integrity, leading to significant yield losses. Recognizing these challenges, our research endeavors have focused on identifying the most harmful moth species during different growth periods, thereby enabling more effective pest management strategies. Chemical control methods were evaluated for their efficacy against the dominant moth species causing damage to tomato crops. Through rigorous testing, specific pesticides were identified that showed substantial effectiveness in controlling these pests. However, it's crucial to approach chemical control with caution to minimize environmental impact and prevent the development of pesticide resistance among moth populations.

1. Introduction

Globally, tomatoes stand out as a pivotal food crop, cultivated in over 100 countries, thanks to their unique health benefits and nutritional value [1]. Recognizing the crucial role vegetables play in enhancing human health, boosting work capacity, and extending life expectancy, there is a significant emphasis on their cultivation and propagation, especially in places like Uzbekistan where agriculture plays a central role in the economy and the well-being of its population [2].

In Uzbekistan, the tomato is not just another vegetable crop; it is regarded as one of the primary vegetable crops, holding a place of honor among the diverse agricultural produce. The popularity of tomatoes in Uzbekistan can be attributed to their superior taste and nutritional benefits. They are a rich source of vitamins, minerals, and a variety of biologically active compounds, including lycopene, a powerful antioxidant that has been linked to reducing the risk of certain types of cancers and heart diseases. Moreover, tomatoes contain vitamin C, potassium, folate, and vitamin K, all of which are essential for maintaining good health, supporting immune function, and preventing aging processes [3, 4].

Given the health benefits associated with tomatoes, there is a strong focus on advancing the methods of cultivation, breeding, and protection to ensure high yields of quality produce [5]. Research and development efforts in Uzbekistan are geared towards improving tomato varieties that are not only resistant to local pests and diseases but also adapted to the climatic conditions of the region. This involves the use of both traditional breeding techniques and modern biotechnologies to develop varieties with enhanced nutritional profiles, better shelf life, and increased resilience to environmental stresses [6].

Furthermore, the government and agricultural institutions in Uzbekistan are actively promoting sustainable farming practices among tomato growers. These practices include the use of integrated pest management (IPM) strategies, efficient water usage through drip irrigation, and the adoption of organic farming practices to minimize the use of chemical fertilizers and pesticides. Such initiatives are crucial for ensuring the sustainable production of tomatoes,

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which in turn contributes to the country's food security, the health of its citizens, and the overall development of its agricultural sector [7, 8].

The burgeoning demand for vegetable products among the Uzbek population, coupled with their increasing nutritional requirements, underscores the pivotal role of both open field and greenhouse cultivation in providing a year-round supply of vitamin-rich vegetable crops. This scenario places a significant emphasis on the expertise of agricultural specialists, who are tasked with the critical roles of selecting seeds from new, high-yielding varieties that exhibit resilience against a spectrum of diseases, pests, and extreme environmental conditions [9, 10]. Moreover, these specialists are responsible for refining cultivation techniques and devising effective strategies to combat diseases and pests, ensuring the robust growth and productivity of these essential crops.

The research aims to develop an integrated pest management (IPM) strategy specifically targeting moths, which are known to cause considerable damage to vegetable crops, including tomatoes. This endeavor necessitates a comprehensive study of the moths' distribution, species diversity, bioecological development patterns, and their impact on crop productivity. By understanding the life cycle and behavior of these pests, specialists can identify critical intervention points and deploy a combination of biological, chemical, cultural, and physical control methods to manage moth populations effectively [11].

A key component of this integrated approach is the use of biological control agents, such as natural predators or parasitoids of the moths, which can significantly reduce their numbers without harming the crops or the environment [12]. Chemical controls, while sometimes necessary, are used judiciously and in combination with other methods to minimize the risk of resistance development and to protect beneficial organisms [13]. Cultural practices, such as crop rotation, proper field sanitation, and the use of resistant varieties, play a crucial role in reducing the prevalence of moths and limiting their damage. Additionally, advancements in technology, including the use of pheromone traps for monitoring and mass trapping, contribute to the early detection and management of moth populations [14].

Ultimately, the goal of this research is to establish a sustainable, environmentally friendly approach to pest management that not only mitigates the impact of moths on vegetable crop productivity but also ensures the production of safe, high-quality vegetables for the people of Uzbekistan. This comprehensive strategy aligns with global trends towards sustainable agriculture and food security, highlighting the importance of scientific research and innovation in meeting the challenges of modern agricultural practices.

2. Materials and Methods

The tasks of the research are to determine the distribution area of moths that cause damage to vegetable (tomato) crops and their type of dominance. The damage caused by moths in different growth periods of the tomato crop is studied. Chemical control of dominant types of moths that cause damage to vegetable (tomato) crops is carried out and their effectiveness is determined.

Distribution of moths in tomato crop, species composition, development characteristics and methods of protection were chosen as the object of research. Various insect acaricides have been used as research subjects to protect moths from tomato crops with pheromone traps and protection.

Propagation of moths was carried out based on methodological manuals [6-9]. An entomological brush was used to estimate the pest during the growth period of tomatoes. The damage caused by artificially infesting the plant with a pest in different growth periods in special crops is compared to the control. The development of the pest was studied according to the development phases of the tomato moth at different temperatures in laboratory conditions. The study of the biological effectiveness of chemical preparations against pests was carried out according to "Methodological guidelines for testing insecticides, acaricides, biologically active substances and fungicides" [13, 14]. Determination of the biological effectiveness of preparations against harmful organisms was carried out [8].

Types of moths that cause damage to vegetable (tomato) crops grown in open fields, their distribution in Uzbekistan, based on the study of bio-ecological characteristics and the damage they cause, it is considered new to create combat methods for reducing the number of moths that cause damage to tomatoes.

3. Results and Discussion

In the experiments carried out by a field scientist in Uzbekistan in 1986-2000, he recorded the occurrence of 51 types of pests belonging to 15 families in crops belonging to the ituzumdash family. Of them, 40 types are found to cause damage to tomatoes and eggplants, and 48 types to potatoes.

According to the results of the research, the diameter of the autumn moth egg is 0.65 mm, the shape is dome-shaped, and there are bumps on the top. On the surface of the egg there are 16 to 20 ribs, some of which go to the end of the egg (the ribbing of moth eggs is a consistent feature of these insects). Newly laid eggs are white.

The wingspan of the autumn moth butterfly is about 40 mm, and the body length is 18-20 mm. Front wings are brown, sometimes yellowish, with dark kidney-shaped spots. The next wings are painted white. Eggs are liquid-colored, 0.65 mm in size, dome-shaped, with 16-20 ribs on the surface, becoming darker as they develop.

The length of the worm reaches 5 cm. The body is shiny, with a tan color, and it is dark-gray in color. The length of the bulb is 14-20 mm, it is light brown in color, and it differs from other moths in that it has two forked spines at the end of the lower part.

According to the studies of Torinyazov (1989), the mature caterpillar of the autumn moth reaches 5 cm. His bluish-grey body had two indistinct paths running from the sides, and between them was a third path, the faint appearance of a dorsal vein. Disturbed, the worm twists and splits. Autumn plowing and autumn-spring irrigation have a negative effect on the wintering of the autumn moth.

Gamma moth (*Authographa gamma* L.) is also a common species. It is a species that feeds mainly on plant leaves and damages many dicotyledonous technical and vegetable crops during the summer season.

Tomatoes and cucumbers are the most common crops grown in greenhouses and are occasionally damaged by the gamma moth. Gamma moth (*Authographa gamma* L.) is one of the most common species. It is a species that feeds mainly on plant leaves and fruits, and damages many dicotyledonous technical and vegetable crops during the summer season. The size (largeness) of the butterfly, fungus and caterpillars is similar to the cotton moth, but a number of morphological characters distinguish it sharply. In particular, the length of the butterfly's wings is 4.5-5.0 cm, the front wings are gray or dark brown in color. The back wings are grayish yellow, and in the center of the wings there is a silvery white spot with the color of the Greek letter gamma (g), hence the name of the pest species.

Bollworm - Heliothis armigera is considered one of the major pests of tomatoes in Uzbekistan, in addition to cotton. All (3-4) stages of the pest can develop in this crop. The pest lays its eggs singly on the stems, flowers and nodes of the plant.

Worms hatched from the eggs gnaw the stems, flowers and fruits of the plant. Each worm can damage 10-12 crop targets. Damaged crops wither, and large ones rot. In some cases (mostly in the Yusupov variety), the affected large fruits do not rot, but may form a scar, but the quality and appearance of the product will be lost. Not all varieties are equally affected by bollworm: the Yusupov variety is the strongest, and the Volgograd 5/95 and Talalikhin varieties are less affected. But there is no type of tomato that is not damaged at all. In some years, the yield can be reduced up to 50%.

According to the results of observations (Toreniyazov et al. 2017), the average daily temperature in December 2015 was 2.8-3.4 ºC. January 2016 showed 0.7-1.1 ºC in the first decade, and 2.5-5.1 ºC in the second decade, and -0.4 ºC in the third. 1.9 ºC, -0.9 ºC and 9.4 ºC in February, 11.1 ºC, 8.2 ºC and 10.5 ºC in March are favorable conditions for moths to hibernate under favorable conditions.

High productivity is achieved if agrotechnical measures are carried out in a timely manner in combination with biological control, determining the spread of pests in vegetable crops, their damage, species composition, bioecological characteristics, and the amount of economic damage.

According to Yusupov et al (2018), Trichogramma is highly effective against moth eggs when applied at a rate of 3 g per hectare (up to 200,000 eggs). It was reported that against moths and worms, bracon was effective when distributed in 1:5, 1:10 and 1:15 ratios.

3.1. Moth control methods in tomatoes

It was mentioned in the literature review that moths can cause severe damage not only in tomatoes, but also in other types of crops. Several preparations have been recommended for the control of these pests in vegetable crops. Many mistakes are made in the use of recommended or used preparations. Farmers are facing problems in pest control as moths and other pests become resistant to preparations due to the high rate of use of pesticides on private farms and farms today. At the same time, it is recognized by experts that the number and viability of the pest is increasing due to the fact that cotton moth worms penetrate into the tomato fruit (more) and cause damage in a hidden state, and the types of crops that moths like to feed on and their area increases. In general, it is always one of the urgent issues to study and improve the terms, methods and means of combating this pest.

In 2018, field experiments were conducted in Tashkent and Kashkadarya regions to determine the biological effectiveness of chemical preparations of different classes against autumn moth in tomatoes.

The results obtained on the biological effectiveness of the preparations sprayed against the autumn moth are presented in Table 1.

Alfamit 40% (0.4-0.5%), Metkiller 90% (0.5-0.6%) and Torpedojet 14% (0.3 -0.4 %) amounts were tested. As a result, Alfamit 40% preparation at 0.4% by the 14th day of calculation - 75.0%; At 0.5%, it was found that 85.1% efficiency was achieved. Metkiller 90% at 0.5% 74.7% on the 14th billing day; showed an efficiency of 91.2% at 0.6%. Also, when Torpedojet 14% preparation is used at 0.4%, the effectiveness on the 14th day is equal to the standard version, and it was determined in our experiments that 84.3% biological efficiency was achieved (Table 1).

We also conducted the above experiments in Kashkadarya region in order to determine the effectiveness of preparations against autumn moth in different soil and climate conditions. In this experiment, due to the older age of

the worms (4-6 years), although the death of the worms was slightly lower, it was confirmed in our observations that the efficiency was almost close to the indicators of the experiments in the Tashkent region (Table 2).

Table 1. Biological effectiveness of preparations used against autumn moths in tomato (Field experiment, Tashkent region (Uzbekistan), Qibray district "Sevara brand style" farm, 2022)

#	Preparation	Active substance	Consumption %	Effectiveness, % by days				
				1	3	7	14	21
1	*Alfamit, 40%*	Methomyl-400 g/kg	0.04	31.3	45.2	51.4	75.0	79.0
2	*Alfamit, 40%*	Methomyl-400 g/kg	0.05	35.6	51.8	76.4	85.1	89.5
3	*Metkiller, 90%*	Methomyl, 90 % SP.	0.05	37.2	57.6	68.9	74.7	84.5
4	*Metkiller, 90%*	Methomyl, 90 % SP.	0.06	48.3	75.6	85.8	91.2	92.3
5	*Torpedojet, 14%*	Indoxicarb 110g/l + emamectin benzoate 30g/l	0.03	33.4	47.2	55.1	72.8	82.1
6	*Torpedojet, 14%*	Indoxicarb 110g/l + emamectin benzoate 30g/l	0.04	40.5	67.4	81.2	84.3	91.2
7	*Decis,2,5%*	Deltamethrin	0.07	50.1	64.4	80.2	85.4	90.1
8	Control	-		-	-	-	-	-
		EKF $_{05}$				2.3		

Table 2. Biological effectiveness of preparations used against autumn moths in tomato (Field experiment, Kashkadarya region (Uzbekistan), Yakkabog district "Tura Ochil" farm 2022)

#	Preparation	Active substance	Consumption %	Effectiveness, % by days				
				1	3	7	14	21
1	*Alfamit, 40%*	Methomyl-400 g/kg	0.04	29.6	37.7	44.6	55.2	68.3
2	*Alfamit, 40%*	Methomyl-400 g/kg	0.05	37.2	50.2	68.7	84.6	88.3
3	*Metkiller, 90%*	Methomyl, 90 % SP.	0.05	38.2	47.6	67.9	72.4	83.2
4	*Metkiller, 90%*	Methomyl, 90 % SP.	0.06	45.3	72.6	88.8	90.0	91.4
5	*Torpedojet, 14%*	Indoxicarb 110g/l + emamectin benzoate 30g/l	0.03	38.4	45.2	54.4	70.6	81.5
6	*Torpedojet, 14%*	Indoxicarb 110g/l + emamectin benzoate 30g/l	0.04	45.5	62.4	80.1	82.2	90.7
7	*Decis 2.5%*	Deltamethrin	0.07	46.3	65.4	81.8	83.4	91.4
8	Control	-		-	-	-	-	-
		EKF $_{05}$				2.1		

3.2. Efficacy of preparation used against hookworms

Timely protection of plants from harmful organisms is one of the most important issues in obtaining a high-quality and high yield from tomato crops. Taking into account that bollworm causes severe damage to tomatoes, we conducted field experiments (during tomato flowering and fruiting) to determine the biological effectiveness of promising preparations against worms of this pest. Knockout 15%, Jayam 5%, Sayver 5%, and Effektum-Duo 40% preparations were included in the scheme of experiments. The results of the preparations used are presented in Table 3.

It was observed that 94.2-96.8% efficiency was obtained on the 14th day when the Knockout 15% preparation was applied against the second generation of bollworm in tomatoes at 0.3-0.4 l/ha. On the 14th day, 85.3% of the total 5% preparation was used at 0.4l/ha, and 0.8l/ha was more effective, reaching 96.9%. 89.6-92.8% was achieved by the 14th day of calculation when Syver 5% was applied at 0.3-0.4 L/L. Effectum-Duo 40% was 91.8% on the 14th day in the case of 0.1l/ha. However, the variant used in the amount of 0.2 l/ha has a higher biological efficiency of the death of cotton moth worms compared to the sample version (Detsis 2.5% - 0.7 l/ha), and it was confirmed in the results of the experiment that it reached 94.6% .

During continuous observations in the fields where the preparations were used, it was observed that the effectiveness of the variants of Sayver and Effektum-Duo preparations against other pests (aphids and spider mites) was satisfactory.

After studying the residues of the preparations used in the experiments on tomato fruits (which will be included in the work program next year), it is recommended to introduce the preparations with high efficiency into production.

Table 3. Biological effectiveness of tested preparations against the second generation of bollworm in tomato ("Sevara brand style" farm field experiment 2021)

Variants	Consumption L/ha	Active substance	Average number of pests in 100 plants				Biological efficiency, days, %		
			Pre-processed	Post-processed, days					
				3	7	14	3	7	14
Knockout 15%	0.3	Indoxacarb	11	2	1.1	0.5	80.4	80.0	94.2
Knockout 15%	0.4	Indoxacarb	12	1.9	5.2	0.3	82.8	90.0	96.8
Jayam 5%	0.4	lambda-cyhalothrin	13	2.1	1.5	1.9	84.7	88.4	85.3
Jayam 5%	0.8	lambda-cyhalothrin	12	0.8	0.7	0.4	92.8	94.2	96.9
Sayver 5%	0.3	Emamectin benzoate	13	0.6	0.5	0.4	95.0	96.2	89.6
Sayver 5%	0.4	Emamectin benzoate	14	1.6	1.2	1.0	87.6	91.4	92.8
Effektum-Duo 40%	0.1	lambda-cyhalothrin+imdoc loprid (100 g/l + 300 g/l)	11	2.0	1.5	0.9	80.3	86.4	91.8
Effektum-Duo 40%	0.2	lambda-cyhalothrin+imdoc loprid (100 g/l + 300 g/l)	15	1.4	1.1	0.8	87.9	92.6	94.6
Decis 2.5%	0.7	Deltamethrin	11	3.0	2.6	1.4	70.4	74.0	81.8
Control	-	-	12	13	12	12	-	-	-
EKF_{05}							2.9		

4. Conclusions

Based on the experiments conducted in 2020, the following recommendations are made for controlling moths in tomatoes:

1. **Autumn Moths**: Use Alfamit 40%, Metkiller 90%, and Torpedojet 14% preparations in the specified amounts. These preparations are effective against autumn moths and can help protect tomato crops from damage.
2. **Second Generation Bollworm**: To combat the second generation of bollworm in tomatoes, the following preparations and application rates are recommended:
    - Knockout 15%: Apply 0.3-0.4 l/ha.
    - Jayam 5%: Apply 0.4 l/ha.
    - Sayver 5%: Apply 0.3-0.4 l/ha.
    - Effektum-Duo 40%: Apply 0.1 l/ha.

These preparations have been found to be effective against bollworm infestations in tomatoes and can help protect the crop from significant damage.

It is important to follow the recommended application rates and safety guidelines when using these preparations to ensure effective pest control and minimize the impact on the environment. Additionally, regular monitoring of the tomato crop for pest activity is advisable to determine the need for further pest management measures.

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