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ORIGINAL ARTICLE

Effectiveness of the application of insecticide preparations against the fall webworm (*Hyphantria cunea* Drury, 1773)

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The effectiveness of chemical and biological preparations in destroying caterpillars of different ages of the fall webworm in the Kharkiv region has been analyzed and studied. The most effective chemical and biological preparations for the destruction of fall webworm caterpillars on ash-leaved maple in forest belts have been determined. Experiments were carried out using the following chemical and biological preparations on ash-leaved maple: Nurel D, 55% emulsion concentrate (standard), Koragen, 20% suspension concentrate, Actofit, 0.2% emulsion concentrate, Lepidocide, water-soluble, titer 1.5×10^9 spores/ml, Bitoxibacillin-BTU, preparative tetro mixture, titer 100×10^9 spores/ml. The preparations were selected according to their purpose and effect on lepidopteran pests and with different active substances. In 2019, it was found that the most effective preparation for destroying caterpillars of younger (L_1-L_3), middle (L_2-L_5) and older (L_6-L_7) ages of first generation of the fall webworm is the preparation Koragen 20% suspension concentrate preparation, which provided mortality in the range of 92.9% to 93.9% on the 14th day of use. The use of the Nurel D insecticide, a 55% emulsion concentrate, contributed to the destruction of caterpillars on day 14 after spraying in the range of 85.6% to 91.7%. Against caterpillars of younger ages (L_1-L_3), middle ages (L_2-L_5), and older ages (L_6-L_7) of the second generation in 2019, the most effective preparation was Koragen 20% suspension concentrate, which provided mortality in the range of 84.5%-92.6% on the 14th day of use. The use of insecticide Nurel D, 55% emulsion concentrate, contributed to the destruction of caterpillars on the 14th day after spraying in the range of 80.3-87.2%. The most effective preparation in destroying caterpillars of the younger (L_1-L_3), middle (L_2-L_5), and older (L_6-L_7) ages of the first generation in 2020 was the preparation of Koragen 20% suspension concentrate, which ensured caterpillar mortality on day 14 after use in the range of 81.5%-93.8%. Insecticide Nurel D, 55% emulsion concentrate, compared to the previous preparation, was less effective and ensured 79.7%-83.7% mortality. In 2020, the use of Koragen 20% suspension concentrate preparation against caterpillars of different ages of the second generation contributed to the destruction of 80.7%-91.7%, and slightly less effectiveness was observed with the use of Nurel D insecticide, a 55% emulsion concentrate, that is, in the range of 73.6%-80.0%. The biological preparations studied Actofit, 0.2% emulsion concentrate, Lepidocide, water-soluble, 1.5×10^9 spores/ml and Bitoxibacillin-BTU tetro preparative mixture, 100×10^9 spores/ml, also contributed to the destruction of caterpillars of the fall webworm of younger, middle and older ages at a reasonably high level. However, their action was somewhat slowed down over time. So on day 14, after nests with caterpillars were sprayed with the biological preparation Bitoxibacillin-BTU tetro preparative mixture, titer 100×10^9 spores/ml in 2019, 76.1% of them were destroyed. In 2020-73.3%, Actofit, 0.2% emulsion concentrate, on the 14th day of research in 2019, 85.3% of younger caterpillars died and in 2020-82.7%. In caterpillar control variant, the death of caterpillars was observed in 2020, starting on the 3rd day, but in 2019, on the 7th and 14th day of the first and second generation in the range of 0.3%-2.8%, respectively, which can be caused by different negative factors and natural enemies of the fall webworm.

Keywords: Fall webworm, chemical preparations, biological preparations, effectiveness.

Introduction

One of the limiting factors in obtaining high yields is pests; taking untimely protective measures leads to a decrease in cropping capacity by 30-45%. Defoliation of plantings leads to a violation of metabolic processes in plants and their weakening, as a result of which the cropping capacity, protective, decorative and aesthetic function decreases, and conditions for the existence of fauna worsen. Individual plants weaken, and with systematic damage by pests, the plants dry up and die. Fruit and berry crops reduce the cropping capacity or do not bear fruit at all in the year of severe damage and the next year (Nakonechna & Stankevych, 2020).

An important place among leaf beetle species is occupied by the fall webworm (*Hyphantria cunea* Drury). In the absence of protective measures, the pest can destroy from 20 to 75% of leaf blades, which, if maximally colonized, leads to a complete lack of yield. The fall webworm (*Hyphantria cunea*) is recognized as a dangerous quarantine pest by many international and regional quarantine and plant protection organizations. These are organizations such as the Asia and Pacific Plant Protection Commission (APPPC), the Regional Plant Protection Committee of South America (COSAVE), and the Eurasian Economic Union (EAEU). In addition, it is included in the lists of quarantine organisms of many countries of the world — partners of Ukraine in international trade. In Ukraine, the pest is included in the A2 list-quarantine organisms that are limited in distribution on the territory of Ukraine.

In Ukraine, the first foci of the fall webworm were discovered in Transcarpathia in June 1952 – almost throughout the region's lowlands. Over the next two years, the pest moved in a northerly direction for 10-15 km, and in the valleys of the Latorytsia, Borzhava and Tysa rivers, individual foci were found in the depths of the foothills (Shumov, 2018; Stankevych, Nakonechna & Manukyan, 2018; Nakonechna, Stankevych, Zabrodina et al, 2019; Nakonechna & Stankevych, 2019; Nakonechna, Stankevych & Kolomiyec, 2019; Nakonechna & Stankevych, 2019).

In the Kharkiv region, the fall webworm was discovered in the early 80s of the twentieth century (Stankevych, 2016; Stankevych, Lezhenina & Zabrodina, 2017; Stankevych, 2017). According to the State Service of Ukraine for Food Safety and Consumer Protection, in 2017, the pest was registered in 24 districts of the Kharkiv region, on a total area of 2429.5 hectares. A significant part of the colonized territory refers to household plots-57.4%, farms of all forms of ownership-19.2%, and other lands-24.4% of the foothills (Nakonechna & Stankevych, 2019a; Nakonechna & Stankevych, 2019b; Nakonechna & Stankevych, 2019c).

The mass distribution of the fall webworm on the territory of the region requires a detailed study not only of the biological and morphological peculiarities and the search for appropriate measures to identify, localize, and eliminate foci. Protection of perennial plantations from the fall webworm is based mainly on extermination measures aimed at destroying the species. However, scientists often recommend the use of an integrated plant protection system against regulated pests. Currently, using a chemical method of controlling harmful organisms is the most effective and economically reasonable. However, alternative environmentally friendly pest control methods are being developed to reduce the negative impact on the environment due to chemical preparations. In our country, the arsenal of microbiological means of protection against leaf beetle pests is quite limited. Researchers note that the use of biological preparations is quite promising in controlling polyphagous pests (Rudenko, Plotnicka & Ignatyuk, 2014).

Materials and Methods

Our research was conducted during 2019-2020 in the Kharkiv region (near the village of Malaya Rohan, 49' 56'19'N, 36' 29'26'E) using generally accepted methods during the growing season. Experiments were carried out using the following chemical and biological preparations on ash-leaved maple: Nurel D, 55% emulsion concentrate (standard), Koragen, 20% suspension concentrate, Actofit, 0.2% emulsion concentrate, Lepidocide, water-soluble, titer 1.5×10^9 spores/ml, Bitoxibacillin-BTU, tetro preparative mixture, titer 100×10^9 spores/ml. The preparations were selected according to their purpose and effect on lepidopteran pests and with different active substances. Working solutions were prepared at the rate of 15 liters of the sprayer and used in three versions: spraying caterpillars at the beginning of revival (before the formation of nests), spraying nests with caterpillars of middle ages and spraying caterpillars of older ages. The percentage of dead caterpillars was determined according to generally accepted methods (Zapolovskij et al., 2013) on the 3rd, 7th, and 14th days after using preparations. In the control variant, trees were sprayed with clean water.

As a result of the conducted studies, it was found that the most effective in destroying the first generation of caterpillars of the fall webworm of younger ages (L_1-L_3) is the preparation Koragen 20% suspension concentrate, which provides 93.9% and 93.8% caterpillar mortality on the 14th day after the use in 2019-2020 (Table 1, 3). The advantage of the preparation is that it has an ovicidal effect. The use of insecticide Nurel D, 55% emulsion concentrate in 2019, contributed to the destruction of 91.7% of the caterpillars of the fall webworm of younger ages on the 14th day after spraying, and in 2020-83.7%, which is 8.0% less. The studied biological preparations Actofit, 0.2% emulsion concentrate, Lepidocide, water-soluble, titer 1.5×10^9 spores/ml, Bitoxibacillin-BTU, tetro preparative mixture, titer 100×10^9 spores/ml, also contributed to the destruction of the caterpillars of the fall webworm of younger ages at a reasonably high level. However, their action was somewhat slowed down in time. So on the 14th day, after spraying nests with caterpillars with the biological product Bitoxibacillin-BTU, tetro preparative mixture, titer 100×10^9 spores/ml in 2019, the death rate was 76.1%, which is 17.8% less than when using the chemical preparation Koragen 20% suspension concentrate, and in 2020-73.3%, which is 20.5% less. Slightly higher effectiveness of action was obtained when using Actofit, 0.2% emulsion concentrate, on the 14th day of the study, when u_{sing} this preparation, the death of 85.3% of the caterpillars of the fall webworm of younger age was observed in 2019, and in 2020-82.7%.

The most effective preparation in the destruction of the caterpillars of younger ages (L_1-L_3) of the second generation in 2019 and 2020 was the preparation of Koragen 20% suspension concentrate, which ensured the mortality of caterpillars on the 14th day after the use (92.6% and 91.0%, respectively). Insecticide Nurel D, 55% emulsion concentrate compared to the previous preparation was less effective-87.2% (2019) and 80.0% (2020). Biological preparations in 2019-2020 also showed significant effectiveness against both younger and middle age caterpillars on the 14th day (Table 2, 4).

Table 1. Technical effectiveness of insecticidal preparations against the fall webworm caterpillars of the first generation in 2019.

S.No	The Name Of The	Consum ption	Number Of Caterpillars Before Treatment,	Technical Effectiveness On-Day

	Preparation	Rate, Kg, l/ Hectare	Specimens/Nest											
			Younger Ages	Middle Ages	Older Ages	Younger Ages			Middle Ages			Older Ages		
						3	7	14	3	7	14	3	7	14
1	Control (H_2O)	0	62.3	58.3	55.9	0	0.8	1.9	1.5	1.7	2.2	2.3	2.	2,8
2	Nurel D, 55% Emulsion concentrate	1	49.5	48.9	50.1	80.8	83.6	91.7	77.9	81.7	85.6	81.6	84.8	87.6
3	Koragen 20% Suspension concentrate	0.15	51.6	52.3	49.6	87.5	90.8	93.9	89.4	93.4	93.8	90.3	93.3	92.9
4	Actofit, 0.2% Emulsion concentrate	2	70.9	69.6	65.5	73.7	81.5	85.3	71.8	75.5	83.3	72.0	75.5	82.7
5	Lepidocide, water Soluble, titer 1.5×10^9 spores/ml	3	71.8	68.6	65.6	69.9	73.3	83.5	68.3	71.4	80.4	77.5	79.4	82.1
6	Bitoxibacillin-BTU, tetro Preparative mixture, titer 100×10^9 spores/ml	0.5	59.5	59.3	56.9	68.7	69.4	76.1	67.1	67.7	74.0	71.1	71.8	74.8
SED_{05}						4.48			4.39			3.42		

Note: SED - the smallest essential difference.

Table 2. Technical effectiveness of insecticidal preparations against the fall webworm caterpillars of the second generation in 2019.

S.No	The name of the preparation	Consumption rate, kg, l/ hectare	Number of caterpillars before treatment, specimens/nest			Technical effectiveness on-day								
			Younger ages	Middle ages	Older ages	Younger ages			Middle ages			Older ages		
						3	7	14	3	7	14	3	7	14
1	Control (H_2O)	0	80.5	87.9	88.9	1.6	1.2	2.1	1.0	0.5	0.6	0.0	0.3	0.5
2	Nurel D, 55% Emulsion concentrate	1	90.5	100.2	95.3	81.1	85.6	87.2	74.3	78.0	80.3	79.8	79.8	82.8
3	Koragen 20% Suspension concentrate	0.15	74.5	85.5	85.9	82.5	87.2	92.6	80.7	81.9	84.5	82.8	82.8	86.1
4	Actofit, 0.2% Emulsion concentrate	2	120.3	110.5	100.0	75.6	78.9	87.1	72.9	74.1	81.3	75.5	75.5	82.0
5	Lepidocide, water Soluble, titer 1.5×10^9 spores/ml	3	95.6	89.9	90.9	72.3	74.4	76.5	67.2	69.9	75.9	75.9	75.9	79.5
6	Bitoxibacillin-BTU, tetro Preparative	0.5	97.9	100.5	110.3	71.3	75.4	78.5	67.9	68.6	71.5	74.7	74.7	79.1

	mixture, titer 100×10^9 spores/ml												
SED_{05}					3.89			3.39			2.11		

Note: SED - the smallest essential difference.

Table 3. Technical effectiveness of insecticidal preparations against the fall webworm caterpillars of the first generation in 2020.

S.No	The Name Of The Preparation	Consumption Rate, Kg, l/ Hectare	Number Of Caterpillars Before Treatment, Specimens/Nest			Technical Effectiveness On-Day								
						Younger Ages			Middle Ages			Older Ages		
			Younger Ages	Middle Ages	Older Ages	3	7	14	3	7	14	3	7	14
1	Control (H_2O)	0	60.5	55.5	57.5	0	0.8	2.4	0.1	0.9	2.7	0.6	0.8	1.2
2	Nurel D, 55% Emulsion concentrate	1	55.5	56.7	56.2	80.1	81.0	83.7	77.9	78.8	79.7	76.8	78.6	80.4
3	Koragen 20% Suspension concentrate	0.15	65.2	65.0	55.0	84.6	86.9	93.8	76.9	77.0	81.5	81.8	83.6	83.8
4	Actofit, 0.2% Emulsion concentrate	2	75.4	65.5	60.5	77.4	80.1	82.7	72.5	75.5	79.3	75.2	76.8	78.5
5	Lepidocide, water Soluble, titer 1.5×10^9 spores/ml	3	68.0	59.0	62.5	75.0	79.4	82.3	71.1	72.8	76.2	72.8	76.0	77.6
6	Bitoxibacillin-BTU, tetro Preparative mixture, titer 100×10^9 spores/ml	0.5	75.0	70.0	65.4	66.6	68.0	73.3	62.8	65.7	71.4	64.8	67.8	72.4
SED_{05}						2.78			2.03			1.54		

Note: SED-the smallest essential difference.

Table 4. Technical effectiveness of insecticidal preparations against the fall webworm caterpillars of the second generation in 2020.

S.No	The Name Of The Preparation	Consumption Rate, Kg, l/ Hectare	Number Of Caterpillars Before Treatment, Specimens/Nest			Technical Effectiveness On-Day								
						Younger Ages			Middle Ages			Older Ages		
			Younger Ages	Middle Ages	Older Ages	3	7	14	3	7	14	3	7	14
1	Control (H_2O)	0	62.5	60.5	60.0	2.0	2.4	2.4	0	0.8	1.6	0	0.8	1.0
2	Nurel D, 55% Emulsion concentrate	1	60.0	55,0	55.6	75.0	76.3	80.0	69.0	72.7	73.6	69.4	73.0	74.8
3	Koragen 20% Suspension concentrate	0.15	50.0	65.0	60.0	80.0	90.0	91.0	76.9	80.0	80.7	78.3	79.1	81.6

4	Actofit, 0.2% Emulsion concentrate Lepidocide, water	2	65.0	60.0	50.5	73.8	76.9	84.6	66.6	68.3	70.0	69.3	70.2	72.3
5	Soluble, titer 1.5×10^9 spores/ml Bitoxibacillin-BTU, tetro	3	50.0	51.0	50.0	68.0	72.0	78.0	64.7	66.6	69.7	68.0	70.0	72.0
6	Preparative mixture, titer 100×10^9 spores/ml	0.5	55.0	62.0	54.5	67.2	70.9	72.7	65.3	66.1	69.3	66.9	67.8	70.6
SED_{05}						5.06			1.51			1.63		

Note: SED-the most minor essential difference.

In 2019-2020, the use of preparations of different origins against the first and second generations of fall webworm caterpillars of the middle ages (L_4-L_5) contributed to their death at a later time than with their use against caterpillars of younger ages (L_1-L_3) as during this period, and the pest forms spider nests. The most effective in destroying the first generation of fall webworm caterpillars of the middle ages (L_4-L_5) on the 14th day after use was also the preparation of Koragen 20% suspension concentrate. The use of the Nurel D insecticide, 55% emulsion concentrate, allowed to destroy 85.6% of fall webworm caterpillars in 2019 and 78.8% in 2020 on the 14th day after use. Among biological preparations for 2019-2020, Actofit, a 0.2% emulsion concentrate, proved to be quite effective in destroying caterpillars of the fourth fifth ages of the fall webworm, namely: on the seventh day after use, 75.5% of caterpillars died, both in 2019 and 2020. The water-soluble biological product Lepidocide, titer 1.5×10^9 spores/ml, was less effective in destroying caterpillars of middle ages (L_4-L_5).

When using the 20% Koragen suspension concentrate chemical insecticide against the second generation of middle-aged caterpillars (L_4-L_5), the effectiveness in 2019-2020 on the 14th day of the experiment was 84.5% and 80.7%, respectively. The use of Nurel D insecticide, a 55% emulsion concentrate in 2019, contributed to the destruction of 80.3% of fall webworm caterpillars of the middle ages on the 14th day after spraying, which is 6.7% less compared to 2020.

The most effective chemical insecticide in destroying older caterpillars of first generation (L_6-L_7) in 2019-2020 was Koragen 20% suspension concentrate, which provided 92.9% and 92.9% death of fall webworm caterpillars on the 14th day after use. Insecticide Nurel D, a 55% emulsion concentrate, showed 87.6% effectiveness in destroying caterpillars on day 14 of the study, 5.3% less than the previous preparation in 2019. Among biological preparations: Actofit, 0.2% emulsion concentrate, Lepidocide, water-soluble, titer 1.5×10^9 spores/ml and Bitoxibacillin-BTU, preparative preparative tetro mixture, titer 100×10^9 spores/ml, Actofit, 0.2% emulsion concentrate proved to be the best and contributed to the death of fall webworm caterpillars 82.7% in 2019 and 2020-78.5% on the 14th day of use, contrast to Lepidocide, water-soluble, titer 1.5×10^9 spores/ml and Bitoxibacillin-BTU, tetro preparative mixture, titer 100×10^9 spores/ml the efficiency of which in 2019 was 82.1% and 74.8%, and in 2020-77.6% and 72.4%, respectively.

In 2019-2020, adequate preparation for the destruction of second generation caterpillars of older ages (L_6-L_7), among those used was Koragen 20% suspension concentrate, which on the 14th day of use showed 86.1% and 81.6% effectiveness. Among biological preparations in 2019 and 2020, Actofit, 0.2% emulsion concentrate, was the most effective and contributed to the death of fall webworm caterpillars 82.0% in 2019 and 72.3% in 2020, which is 9.7% less compared to 2019.

In caterpillar control variant, the death of caterpillars was observed in 2020 beginning on the third day, but in 2019 the death of caterpillars of the first and second generation was in the range of 0.3%-2.8%, respectively, which can be caused by various negative factors and natural enemies of the fall webworm.

Conclusion

As a result of the conducted studies, it was established that under the conditions of the Kharkiv region, when using insecticidal preparations of chemical and biological origin (Nurel D, 55% emulsion concentrate (standard), Koragen, 20% suspension concentrate, Actofit, 0.2% emulsion concentrate, Lepidocide, water-soluble, titer 1.5×10^9 spores/ml, Bitoxibacillin-BTU, preparative tetro mixture, titer 100×10^9 spores/ml) against fall webworm caterpillars of different ages, high effectiveness can be achieved. According to our research, the maximum result was obtained on the 14th day of the experiment against caterpillars of younger ages (L_1-L_3) of the first generation-93.8% and the second-91.0%, using the Koragen 20% suspension concentrate chemical preparation. Using this insecticide against middle (L_4-L_5) and older caterpillars (L_6-L_7) also achieved the highest positive result. Among biological preparations for the destruction of fall webworm caterpillars of different ages, Actofit, 0.2% emulsion concentrate, showed a high level. The results of the studies carried out make it possible to state that, for the control of fall webworm caterpillars of different ages, it is advisable to use insecticides of different chemical groups and actions, including preparations based on biological agents. However, a somewhat slow action characterizes them.

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