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ORIGINAL ARTICLE

Efficiency of chemical protection of spring rape and mustard from cruciferous bugs

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The complex of cruciferous bugs includes such species as painted or harlequin (cabbage) bug (*Eurydema ventralis* Kol), pentatomid rape bug (*E. oleraracea* L.), and mustard bug (*E. ornata* L.). They belong to Hemiptera, the family Shield bugs (Pentatomidae), and the genus Cruciferous bugs (*Eurydema*). The dominant species is the cabbage bug. The mustard bug dominated only in 2007, and since 2012 it has not been detected in the records. They are widespread throughout the whole territory of Ukraine. Both adult bugs and larvae cause damage to the crops; they pierce the leaf skin or floriferous shoots with the proboscis and suck out the juice. The light spots appear at the puncture points, the tissue dies, falls out, and the irregular form holes are formed. When the seeds are damaged, the flowers and ovary fall off, and the quality of the seeds deteriorates. The harmfulness of the bugs increases dramatically in dry and hot weather. As a result of the researches, it is found out that in 2012−2014 the average technical efficiency of the Biscaya preparation, 24% of oily dispersion on spring rape in 3 days after spraying was 87.7%, in 7 days it was 58,4%, and in 14 days it was 47.9%; on white mustard the technical efficiency was 92.2, 83.0, and 69.5% respectively. As for Chinese mustard, the efficiency was 92.4, 83.1, and 66.7%. The technical efficiency of the insecticides Mospilan, 20% of soluble powder and Nurelle D, 55% of emulsion concentrate is somewhat lower than that of the Biscaya insecticide, 24% of oily dispersion, and, depending on the cultivated crop, in 3 days the technical efficiency was 77.4–83.6% and 78.4–82 0% respectively, in 7 days it was 52.8–74.5% and 68.0–75.5%, in 14 days the efficiency was 49.1−65.5% and 49.0−62.0% respectively. At the Educational, Research and Production Centre “Research Field” spraying with the Biscaya insecticide ensured saving of the spring rape yield up to 0.249 t/ha, the yield of white mustard was saved at the level of 0.133 t/ha, and the yield of Chinese mustard was saved at the level of 0.201 t/ha. The applying of the Mospilan insecticide, 20% of soluble powder on spring rape crops contributed to saving the yield at the level of 0.317 t/ha, the yield of white mustard was saved at the level of 0.125 t/ha and the yield of Chinese mustard was saved at the level of 0.273 t/ha. Spraying with the preparation Nurelle D, 55% of emulsion concentrate ensured the yield up to 0.344, 0.093, and 0.261 t/ha, respectively.
Keywords: spring rape**,** mustard, pests, harmfulness, cruciferous bugs, measures of protection.

Introduction

The complex of cruciferous bugs includes such species as painted or harlequin (cabbage) bug (*Eurydema ventralis* Kol), pentatomid rape bug (*E. oleraracea* L.), and mustard bug (*E. ornata* L.). They belong to Hemiptera, the family Shield bugs (Pentatomidae), and the genus Cruciferous bugs (*Eurydema*). The cruciferous bugs are a common species and are spread throughout the Palaearctic. They are widespread throughout the whole territory of Ukraine (Puchkov, 1961; Yevtushenko, Vilna, Stankevych, 2016).

The imago of the cabbage bug is 6-10 mm long; its body is flattened, the prothorax is red with six black spots, on the shield and elytra there are black spots and stripes (Fig. 1); the antennae are 5-segmented; a triangle scutellum covers a more significant part of the abdomen, the legs are 3-segmented. The imago of the mustard bug is 6-10 mm in size; the body is flattened, the

prothorax is yellow with six black spots, on the shield and elytra, there are black spots and stripes (Figure 1). The imago of the rape bug is 6-10 mm in size; the body is flattened, the prothorax is white with 6 black spots, on the shield and elytra, there are black spots and stripes (Figure 1). The egg is 0,6–0,8 mm in size, cylindrical; the bottom is rounded, the top is covered by a convex lid that opens when the larvae hatch (Figure 1). The larva of the imago is similar (Fig. 1).

Fig. 1. Cruciferous bugs: 1. oviposition; 2. reappearance of larvae; 3. larva and signs of damage; 4. rape bug; 5. mating of cabbage bugs; 6. mustard bugs (photo by the author, Educational, Research and Production Centre "Research Field" of Kharkiv National Agrarian University named after V.V. Dokuchaiev, 2018)

The immature bugs overwinter under the fallen leaves at the edge of forest belts, gardens, and parks, on the beams slopes and roadsides. In April and May, they leave the wintering places. In addition, they feed on the cabbage weeds, and with the emergence of the cultivated cabbage plants, sprouts, and seedlings transplanting, the bugs' mass flies over to them. The female lays 12 eggs in a group, placing them in two rows, more often on the underside of the leaves. The fertility is up to 300 eggs. The embryonic development lasts for 6–12 days. The larvae feed on the plants for 25–40 days turning into an adult insect. After the extra feeding, the bugs give birth to the second generation, which develops in July and August. Both the adult bugs and larvae cause damage to the crops; they pierce the leaf skin or floriferous shoots with the proboscis and suck out the juice. The light spots appear at the puncture points, the tissue dies, falls out, and the holes of the irregular form are formed. When the seeds are damaged, the flowers and ovary fall off, and the quality of the seeds deteriorates. The economic threshold of harmfulness is 2–3 bugs per plant (Puchkov, 1961; Yevtushenko, Fedorenko, Stankevych, 2009; Stankevych, Vilna, 2012; Vilna, 2013; Vilna, Stankevych, 2013; Stankevych, Kava, 2013; Yevtushenko, Vilna, 2014; Vilna, Yevtushenko, Stankevych, 2015; Stankevych, 2015; Yevtushenko, Vilna, Stankevych, 2016).

Materials and methods

The development of the cruciferous bugs was observed in the entomological insulators (sweep nets) made from agricultural fiber. The pests were counted according to the generally accepted method (Omeliuta, 1986; Stankevych, Zabrodina, 2016).

The insecticides that we used during the vegetation period to control the cruciferous bugs had been tested on the plots where the number of the pests exceeded the economic threshold of harmfulness. The insecticides were applied against the same agro-technical background and in the same phase of the plant development (Dospiekhov, 1985; Triebel, 2001). All the experiments were done at the Educational, Research and Production Centre "Research Field" of Kharkiv National Agrarian University named after V.V. Dokuchaiev

Spraying of the plots was carried out with a knapsack sprayer of the "Lemira – SP – 202–01" brand at the consumption rate of about 250 L/ha: 1. Control (H2O); 2. Biscaya, 24% of oily dispersion (0.25 L/ha). The variants of the research in 2014 are the following: 1. Control (H2O); 2. Biscaya, 24% of oily dispersion (0.25 L/ha); 3. Mospilan 20% of soluble powder (0.05 kg); 4. Nurelle D, 55% of emulsion concentrate (1.0 L/ha).

The acreage of the experimental plots where the insecticides controlling the cruciferous bugs were tested accounted for 5 m² in triplicate. After 3, 7, and 14 days, the areas of 1 m² on each plot were examined, and the bugs' population density was determined.

When spraying the crops, the technical efficiency of the preparations against the main rape pests was determined by the formula:

$$T = \frac{a-b}{a} \times 100, \quad (1)$$

where T— technical efficiency, %;

a — density of the pests population before spraying,

b — density of the pests population in 3, 7, or 14 days after spraying (Recommendations, 1975; Methods of calculation, 1976; Triebel and others, 2001; Stankevich, Zabrodina, 2016).

The economic efficiency or increase in the yield was determined according to the following formula:

$$I = \frac{a-b}{a} \times 100, \quad (2)$$

where *I* — increase in the yield, %;

a — average yield from a calculated unit on a cultivated plot, t;

b — average yield from a calculated unit on a plot under control, t (Recommendations, 1975; Methods of calculation, 1976; Triebel and others, 2001; Stankevich, Zabrodina, 2016).

The statistical data analysis, the correlation analysis, and the analysis of variance (Dospiekhov, 1985) were performed with the help of MS Excel.

Results and discussion

In 2012–2013 in order to protect the plants of spring oilseed cabbage crops from the damages caused by the cruciferous bugs on the experimental crops of the Educational, Research and Production Centre "Research Field," the spraying of crops in the phenophase of the yellow bud with the systemic Biscaya insecticide, 24% of oily dispersion was carried out. The plot under control was sprayed with water. Such spraying was used against the cabbage and rape bugs, cabbage aphids, and rape blossom beetle, which, depending on the year, caused a decrease in the yield capacity and its quality. The acreage of the experimental plots under spring rape and mustard where the insecticide controlling the cruciferous bugs was tested accounted for 5 m² in triplicate. After 3, 7, and 14 days after spraying, the area of 1 m² on each plot was examined, and the population density of the bugs per 1 plant was determined.

As a result of spraying the crops of oilseed cabbage with the insecticide of systemic action Biscaya, 24% of oily dispersion at the rate of consumption of 0.25 L/t in the phenophase of the yellow bud we have found out that spraying of the spring rape and mustard crops protected from the cruciferous bugs.

In the research, the data regarding the technical efficiency of spraying were obtained (Tables 1–3). They indicate that the preparation of Biscaya, 24% of oily dispersion has quite enough toxic effect on the cabbage and rape bugs.

Table 1. Technical efficiency of insecticide Biscaya, 24% of oily dispersion when protecting spring rape of Ataman variety from cruciferous bugs in phenophase of a yellow bud

Variant	2012			2013			2014			Average in 2012–2014		
	Technical efficiency (%) in 3, 7, and 14 days after spraying											
	3	7	14	3	7	14	3	7	14	3	7	14
Control (H_2O)	–	–	–	–	–	–	–	–	–	–	–	–
Biscaya, 24% of oily dispersion (0.25 L/ha)	88.9	57.6	47.2	84.1	55.4	43.3	90.2	62.4	53.4	87.7	58.4	47.9
HIP_{05}	3.52											

Table 2. Technical efficiency of insecticide Biscaya, 24% of oily dispersion when protecting white mustard of Carolina variety from cruciferous bugs in phenophase of a yellow bud

Variant	2012			2013			2014			Average in 2012–2014		
	Technical efficiency (%) in 3, 7, and 14 days after spraying											
	3	7	14	3	7	14	3	7	14	3	7	14
Control (H_2O)	–	–	–	–	–	–	–	–	–	–	–	–
Biscaya, 24% of oily dispersion (0,25 L/ha)	90.4	81.2	68.3	92.4	83.7	69.8	93.8	84.2	70.4	92.2	83.0	69.5
HIP_{05}	2.22											

For the years of the researches, the average technical efficiency in 3 days after spraying constituted 87.7% on spring rape, on white mustard, it was 92.2%, and on Chinese mustard, it was 92.4% (Tables 1–3). In 7 days after spraying, the technical efficiency constituted 58.4% on spring rape, on white mustard, it was 83.0%, and on Chinese mustard, it was 83.1%. In 14 days after spraying, the technical efficiency amounted to 47.9% on spring rape, on white mustard, it was 69.5%, and on Chinese mustard, it was 66.7%. A little lower technical efficiency of the Biscaya insecticide, 24% of oily dispersion on the crops of spring rape, can be explained by the fact that this crop was populated by the cruciferous bugs much more than mustard.

Table 3. Technical efficiency of insecticide Biscaya, 24% of oily dispersion when protecting Chinese mustard of Tavrychanka variety from cruciferous bugs in phenophase of a yellow bud (in 2012-2014)

Variant	2012			2013			2014			Average in 2012–2014		
	Technical efficiency (%) in 3, 7, and 14 days after spraying											
	3	7	14	3	7	14	3	7	14	3	7	14
Control (H_2O)	–	–	–	–	–	–	–	–	–	–	–	–
Biscaya, 24% of oily dispersion (0.25 L/ha)	91.2	85.3	65.7	92.7	81.1	66.9	93.5	82.9	67.6	92.4	83.1	66.7
HIP_{05}	3.26											

In 2014, to protect the crops of spring rape, white mustard, and Chinese mustard, the insecticides Mospilan, 20% of soluble powder (0.1 kg/ha), and Nurelle D 500 emulsion concentrate (1 L/ha) were also used. The data obtained (Table 4) indicate a sufficient toxic effect on the cruciferous bugs. Thus after three days, the technical efficiency of the Mospilan preparation on the crops of spring rape of Ataman variety was 77.4%, after seven days, it was 52.8%, and after 14 days, the efficiency was 49,1%. The preparation Nurelle D showed a little more toxicity; when applying this preparation, the technical efficiency on the 3rd, 7^{th,} and 14th days was 81.6%, 75.5%, and 49.0%, respectively.

The opposite tendency of the toxic effects of the Nurelle D and Mospilan preparations is observed in the cultivation of white and Chinese mustards. When applying Mospilan on the crops of white mustard of Carolina, the technical efficiency on the 3rd, 7^{th,} and 14th days was 83.6%, 74.5%, and 65.5%, respectively. A little lower technical efficiency was when applying the Nurelle D insecticide; in 3 days, the efficiency was 82.0%, in 7 days, it was 68.0%, and in 14 days, the efficiency was 62.0%.

Table 4. Technical efficiency of insecticides Mospilan, 20% of soluble powder (0.1 kg/ha) and Nurelle D 500 emulsion concentrate (1.0 L/ha) when protecting spring rape of Ataman variety, white mustard of Carolina variety, and Chinese mustard of Tavrychanka variety from cruciferous bugs in phenophase of a yellow bud (in 2014)

Variant	Technical efficiency (%) in 3, 7, and 14 days after spraying								
	Spring rape			White mustard			Chinese mustard		
	3	7	14	3	7	14	3	7	14
Control (H_2O)	–	–	–	–	–	–	–	–	–
Mospilan, 20% of soluble powder (0.1 kg/ha)	77.4	52.8	49.1	83.6	74.5	65.5	80.8	67.3	55.8
Nurelle D, 55% of emulsion concentrate (1.0 L/ha)	81.6	75.5	49.0	82.0	68.0	62.0	78.4	68.6	56.9
HIP_{05}	2.68								

Spraying of Chinese mustard crops of Tavrychanka variety with Mospilan showed a relatively high technical efficiency against the cruciferous bugs, which amounted to 80.8% on the 3rd day, 67.3% 7th day, and 55.8% on the 14th day. When applying Nurelle D, the technical efficiency was slightly lower than that of Mospilan and was 78.4%, 68.6%, and 56.9% on the 3rd, 7th and 14th days. Therefore, the preparations Mospilan and Nurelle D have a reasonably high toxic effect on the bugs, but their toxic effect is lower than that of the Biscaya preparation.

The stabilization of the phytosanitary condition of agrocoenosis of spring oilseed cabbage crops and its ecological safety is the final result of the integrated protection of these crops. The stable functioning of agrocenosis and phytosanitary stability is achieved by selecting the appropriate varieties, minimizing the insecticide application, preserving the valuable entomofauna, strengthening the biocoenosis regulation, and preventing mass reproduction of the harmful insect species. The crucial importance in reducing the harmful effects of cruciferous bugs belongs to the chemical method.

To protect the crops of spring rape and mustard from the cruciferous bugs we had carried out the spraying with the Biscaya insecticide 24% of oily dispersion at the consumption rate of 0.25 L/ha in the phenophase of the yellow bud before flowering. This provided quite high technical as well as the economic efficiency in controlling the cruciferous bugs and rape blossom beetles, the main pests of the generative organs of the oilseed cabbage crops in the Eastern Forest-Steppe of Ukraine. All the experiments were done at Educational, Research and Production Centre "Research Field" of Kharkiv National Agrarian University named after V.V. Dokuchaiev,

Spraying with the insecticide Biscaya, 24% of oily dispersion with the consumption rate of 0.25 L/ha in controlling the cruciferous bugs contributed to saving the yield of spring rape crops of Ataman variety by more than 0.117 t/ha in 2012, in 2013 the yield was saved by more than 0.103 t/ha, and in 2014 it was saved by more than 0.528 t/ha (Table 5). For the three-years researches, the saved yield amounted to 0.249 t/ha on average.

Table 5. Economic efficiency of insecticide Biscaya, 24% of oily dispersion when protecting spring rape of Ataman variety from cruciferous bugs in phenophase of a yellow bud (in 2012-2014)

	Year							
	2012		2013		2014		Average in 2012–2014	
Variant	Yield capacity, t/ha	Yield saved, t/ha	Yield capacity, t/ha	Yield saved. t/ha	Yield capacity t/ha	Yield saved, t/ha	Yield capacity, t/ha	Yield saved, t/ha
Control (H_2O)	0.085	–	0.091	–	0.563	–	0.246	–
Biscaya, 24% of oily dispersion (0.25 L/ha)	0.202	0.117	0.194	0.103	1.091	0.528	0.495	0.249
HIP_{05}	0.005	-	0.003	-	0.068	-	-	-

In 2012 when protecting white mustard of Carolina variety from the cruciferous bugs, the yield capacity was 0.107 t/ha higher than that one without spraying with the insecticide; in 2013, the yield capacity was 0.135 t/ha higher, and in 2014, it was 0.156 t/ha higher (Table 6). When spraying the crops of Chinese mustard of Tavrychanka variety with the Biscaya insecticide, 24% of oily dispersion and ensuring the protection from the cruciferous bugs, we have obtained a significantly higher yield the yield obtained without chemical protection (Table 7). Thus in 2012, in the variant with the insecticide, the yielded crops were at the level of 0.214 t/ha, which is 2.2 times higher than in the control variant; in 2013, the yielded crops were at the level of 0.223 t/ha (2.18 times higher), and in 2014 the yielded crops were at the level of 0.853 t/ha (1.75 times higher); 0.201 t/ha on average was saved in 2012–2014.

Table 6. Economic efficiency of insecticide Biscaya, 24% of oily dispersion when protecting white mustard of Carolina variety from cruciferous bugs in phenophase of a yellow bud (in 2012-2014)

	Year							
	2012		2013		2014		Average in 2012–2014	
Variant	Yield capacity, t/ha	Yield saved, t/ha	Yield capacity, t/ha	Yield saved. t/ha	Yield capacity t/ha	Yield saved, t/ha	Yield capacity, t/ha	Yield saved, t/ha
Control (H_2O)	0.103	–	0.121	–	0.162	–	0.128	–
Biscaya, 24% of oily dispersion (0.25 L/ha)	0.210	0.107	0.256	0.135	0.318	0.156	0.261	0.133
HIP_{05}	0.011	-	0.016	-	0.004	-	-	-

Table 7. Economic efficiency of insecticide Biscaya, 24% of oily dispersion when protecting Chinese mustard of Tavrychanka variety from cruciferous bugs in phenophase of a yellow bud (in 2012-2014)

Variant	Year 2012		2013		2014		Average in 2012–2014	
	Yield capacity, t/ha	Yield saved, t/ha	Yield capacity, t/ha	Yield saved. t/ha	Yield capacity t/ha	Yield saved, t/ha	Yield capacity, t/ha	Yield saved, t/ha
Control (H_2O)	0.096	–	0.102	–	0.488	–	0.228	–
Biscaya, 24% of oily dispersion (0.25 L/ha)	0.214	0.118	0.223	0.121	0.853	0.365	0.430	0.201
HIP_{05}	0.010	-	0.016	-	0.012	-	-	-

Table 8. Economic efficiency of insecticides Mospilan and Nurelle D 500 when protecting spring rape of Ataman variety, white mustard of Carolina variety and Chinese mustard of Tavrychanka variety from cruciferous bugs in phenophase of a yellow bud (in 2014)

Variant	Spring rape		White mustard		Chinese mustard	
	Yield capacity, t/ha	Yield saved, t/ha	Yield capacity, t/ha	Yield saved. t/ha	Yield capacity t/ha	Yield saved, t/ha
Control (H_2O)	0.563	–	0.162	–	0.488	–
Mospilan, 20% of soluble powder (0.1 kg/ha)	0.880	0.317	0.287	0.125	0.761	0.273
Nurelle D, 55% of emulsion concentrate (1.0 L/ha)	0.907	0.344	0.255	0.093	0.749	0.261
HIP_{05}	0.010	-	0.011	-	0.011	-

Thus, depending on the crop, the average economic efficiency of spraying with the systemic insecticide Biscaya, 24% of oily dispersion at the rate of consumption of 0.25 L/ha 0.133–0.249 t/ha (Tables 5–7).

The use of Mospilan on the crops of spring rape of Ataman variety contributed to saving the yield at the level of 0.317 t/ha, the yield of white mustard of Carolina variety was saved at the level 0.125 t/ha, and the yield of Chinese mustard of Tavrychanka variety was saved at the level of 0.273 t/ha (Table 8). Spraying of spring rape, white mustard, and Chinese mustard crops with the preparation Nurelle D ensured saving the yield at the level of 0.344 t/ha, 0.093 t/ha, and 0.261 t/ha, respectively. On the whole, the use of the insecticides Mospilan and Nurelle D provided a yield capacity 1.53-1.77 times higher than the yield capacity without spraying the crops with the insecticides.

Conclusions

The cruciferous bugs (*Eurydema* spp.) are a counterpart of the complex of the main pests of the cabbage crops generative organs in the Eastern Forest-Steppe of Ukraine. three species present the cruciferous bugs: painted or harlequin (cabbage) bug (*Eurydema ventralis* Kol), pentatomid rape bug (*E. oleraracea* L.) and mustard bug (*E. ornata* L.).

In 2012−2014, the average technical efficiency of the Biscaya preparation, 24% of oily dispersion on spring rape in 3 days after spraying was 87,7%, in 7 days it was 58.4%, and in 14 days it was 47.9%; on white mustard the technical efficiency was 92.2, 83.0, and 69.5% respectively. As for Chinese mustard, the efficiency was 92.4, 83.1, and 66.7%. The technical efficiency of the insecticides Mospilan, 20% of soluble powder and Nurelle D, 55% of emulsion concentrate is relatively lower than that of the Biscaya insecticide, 24% of oily dispersion, and, depending on the cultivated crop, in 3 days the technical efficiency was 77.4–83.6% and 78.4–82.0% respectively, in 7 days it was 52.8–74.5% and 68.0–75.5%, in 14 days the efficiency was 49.1−65.5% and 49.0−62.0% respectively.

At the Educational, Research and Production Centre “Research Field,” spraying with the Biscaya insecticide ensured saving of the spring rape yield up to 0.249 t/ha, the yield of white mustard was saved at the level of 0.133 t/ha. The yield of Chinese mustard was saved at the level of 0.201 t/ha. The applying of the Mospilan insecticide, 20% of soluble powder on spring rape crops, contributed to saving the yield at 0.317 t/ha. The yield of white mustard was saved at 0.125, and the yield of Chinese mustard was saved at 0.273 t/ha. Spraying with the preparation Nurelle D, 55% of emulsion concentrate ensured the yield up to 0.344, 0.093 and 0.261 t/ha, respectively.

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