

ORIGINAL ARTICLE

Harmfulness of pea pod borer (*Etiella zinckenella* Tr. 1832) in soybeans in the eastern Forest-Steppe of Ukraine

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Soybean is the main leguminous crop in the world. Its grain is balanced in protein and digestible amino acids. Among the dangerous soybean pests, scientists distinguish pea pod borer (leguminous) (*Etiella zinckenella* Tr.). Our research on soybean crops was carried out during 2018-2020 in the state enterprise 'Experimental Farm' Elitne', Kharkiv district, Kharkiv region. The plants were examined for the presence of pea pod borer caterpillars and damaged beans. All the results obtained were processed and inserted into tables. The number of caterpillars in soybean plants in 2018 ranged from 2 to 29 specimens/100 plants, in 2019 from 2 to 22 specimens/100 plants, in 2020 from 2 to 21 specimens/100 plants. When soybean plants were examined, the damage was also found to beans and seeds. In 2018, the percentage of damage ranged from 0.3% to 3.7%, in 2019 from 0.2% to 0.9% and in 2020 from 0.6% to 1.8%. The percentage of damaged seeds was: in 2018-from 0.2% to 3.4%, in 2019-from 0.1% to 0.8% and in 2020-from 0.6% to 1.8%. In our study, we conducted experiments on damaged seeds by pea pod borer under laboratory conditions of V. Ya. Yuriev Institute of Plant Cultivation of NAAS. We have done a seed analysis for fat and protein content. On average, for 2018-2020, the following data were obtained: undamaged seeds contained 37.05% protein, 21.10% fat, and damaged seeds-38.61% and 19.75%, respectively. During 2018-2020, soybean crops were monitored for pea pod borer caterpillars, and the most colonized varieties were sprayed with insecticides. In 2018, Nurel D showed the greatest technical efficiency on day 3, 55% emulsion concentrate (1.0 l/ha)-28%, on day 7-Antygusin, 50% suspension concentrate (0.15 l/ha)-59%, on day 14-Preparation Koragen, 20% suspension concentrate. (0.2 l/ha)-82%; in 2019, the best technical efficiency on day 3 was shown by Antygusin preparation, 50% suspension concentrate (0.15 l/ha) -33%, on day 7-also preparation Antygusin, 50% suspension concentrate (0.15 l/ha) -53%, on day 14 - Koragen preparation, 20% suspension concentrate (0.2 l/ha)-73%; in 2020, the best technical efficiency on day 3 was shown by Chlorpyrivit-agro, 55% emulsion concentrate (1.0 l/ha)-29%, on day 7-Antygusin, 50% suspension concentrate (0.15 l/ha)-52%, on 14 day preparation Koragen, 20% suspension concentrate (0.2 l/ha)-81%.

Keywords: Legumes, soybeans, pests, pea pod borer, harmfulness, damage.

Introduction

Soybean is one of the most important crops in world agriculture and is used successfully to solve the problem of increasing vegetable protein and oil production. Pea pod borer (*Etiella zinckenella* Tr.) is a pest that can destroy soybean yield up to 90%. The harmfulness of pea pod borer reduces the grain yield (the seeds of damaged beans are partially or entirely eaten inside), spreading bacterial and fungal diseases on the damaged grain.

The pea pod borer (*Etiella zinckenella* Tr.) is a dangerous pest in soybean crops. Active colonization is facilitated by the close placement of crops from Siberian pea shrub and locust tree plantations. The natural habitat of the pea pod borer (legume) (*Etiella zinckenella* Tr.) covers the central part of Russia (mainly in the steppe zone and the southern part of the Forest-Steppe of the European part), the North Caucasus, southern Siberia, the Far East, the Baltic states, Belarus, Ukraine, Moldova, Transcaucasia, Kazakhstan, Central Asia, Western Europe (up to southern Finland), North America, Asia Minor, the Middle East, India, China, Korea, Japan, Southeast Asia. The pest is also imported to Australia and America (Graham, 1976; Lutytska, Stankevych, Zabrodina et al., 2019).

Russian scientists A.N. Frolov and M.I. Saulych (Luticka & Stankevych, 2019;

http://www.agroatlas.ru/ru/content/pests/Etiella_zinckenella/map/) compiled the area of the prevalence of pea pod borer and zones of its harmfulness, within which the zone of average harmfulness is distinguished (south of Ukraine, Krasnodar and Stavropol territories, Rostov region, lower Volga region), where the loss of leguminous on average can be 5-6%; the zone of weak harmfulness, where yield losses, as a rule, are below 5% of the limit, in the European part of the former USSR, it covers the territory of legumes growing, in the Asian part-the territory of soybean cultivation with an average July temperature of at least 20 C.

In Ukraine, the species is widespread everywhere, but more numerous and harmful in the Steppe and the south of the Forest-Steppe. It damages pea, lentil, bean, soybean, lupine, locust tree, and Siberian pea shrub, honey locust, in Transcarpathia-hazelnut, watermelon seeds. The number of pea pod borers and their harmfulness increases in dry years. The proximity of soybean crops to the plantations of the Siberian pea shrub and locust tree facilitates greater colonization of beans. According to V. I. Sichkar and O. A. Hrykun (Sichkar & Hrykun, 1982), in Odessa, Mykolaiv, Crimea, and other regions, pea pod borer causes grain loss of up to 1-2 centners/ha of grain and significantly reduces the quality of grain.

Caterpillars of this pest live in beans, feed on young seeds, and often move from one bean to another. In this region, during the spring and summer period, the peapod borer usually produces two generations: the first develops on the Siberian pea shrub, pea, and the second generation on the soybean and locust tree. Given the great harmfulness of this pest, they studied the variability of damage depending on the genotype of the plant and weather conditions, as well as some resistance mechanisms. Similar studies of the Mexican bean beetle, Chloridea cotton moth, leafroller, and other pests are conducted in the United States and Brazil (Graham, 1976; Schillinger, 1976; Smith & Brim, 1979).

As source material, we used a large set of collected samples of soybean varieties from different parts of the world and promising breeding numbers created at the All-Union Breeding and Genetic Institute (Odessa). For a reliable assessment, a favorable background was created to increase the number of pests. The experimental plot was located near the plantations of the Siberian pea shrub and locust tree (no more than 100 m), which are natural reserves of the pea pod borer. Several rows of peas were seeded around the perimeter, which made it possible to create a high density of the first generation of the pest. The samples were studied for three and more years. The degree of damage was calculated mainly during the phase of full ripeness in the laboratory. Damaged beans were opened, and the number of fully or partially damaged seeds was counted. The flight dynamics of second-generation butterflies were studied under field conditions. To do this, we watched the pest's flight for 20-30 days, using a light trap. Butterflies were caught every day or in a day, depending on the activity of the flight, as well as weather conditions (the light trap was not turned on in rainy weather) (Sichkar, Lopatina & Grikun, 1991).

Materials and Methods

The research aims to monitor the colonization of soybean crops by the pea pod borer and determine the level of damage to beans and soybean grain.

Our research on soybean crops was carried out during 2018-2020 in the Kharkiv district of the State Enterprise 'Experimental Farm' Elitne, Kharkiv region. Plants were examined for the presence of pea pod borer caterpillars and to determine the percentage of damage to beans and seeds (Luticka & Stankevych, 2018b; Luticka & Stankevych, 2019a).

There are only 26 varieties of Ukrainian and Canadian selection in the field. Soybeans were sown in three terms of sowing, so there was an opportunity to track the development and harmfulness of the pea pod borer in plants in different phases of the growing season. With the help of selecting method, we determined 10 plants in 10 locations (a sample of 100 plants) on each variety and made calculations. All data obtained were processed and inserted into tables (Luticka & Stankevych, 2018a; Luticka & Stankevych, 2019b).

During the route survey of soybean crops, the presence of pea pod borer caterpillars in beans was monitored. Long-term data are inserted into Table 1.

According to the table, the smallest number of pea pod borer caterpillars in 2018 was recorded in Sprytyna, Malvina (III decade of April), Raiduga, ES Mentor (II decade of May) 2 specimens/100 plants. All caterpillars were of Malvina variety (III decade of May)-29 specimens/100 plants.

In 2019, the lowest number was in the Biliavka, Vyshyvanka, ES Mentor, Aligator varieties (II decade of May) 2 specimens/100 plants. The Biliavka variety had the most significant number (III decade of April)-22 specimens/100 plants.

In 2020, the smallest number of caterpillars was observed in the Biliavka and Malvina varieties (III decade of May), Korada, ESC Senator (II decade of May) 2 specimens/100 plants. Most of the all on soybean crops of Sprytyna variety in the amount of 21 specimens/100 plants.

To determine the percentage of damage to beans by pea pod borer in soybean crops, intact and damaged generative organs were calculated in each variety and three sowing terms. Ten plants were selected for each variety at 10 locations. Data are inserted into Tables 2, 3, 4.

According to Table 2 in the first sowing period (III decade of April), the number of beans per 100 plants ranged from 2431 pieces/100 plants in the Biliavka variety to 3294 in the Malvina variety; in the second sowing period (II decade of May) it reached 2341 pieces/100 plants in the Krasunia variety to 3531 pieces/100 plants in the Aligator variety; in the third period (III decade of May), the number of beans per 100 plants ranged from 2598 pieces/100 plants in the Sprytyna variety to 2842 pieces/100 plants in the Malvina variety.

Table 1. Colonization of soybean varieties by pea pod borer caterpillars depending in the sowing period in 2018-2020 in the State Enterprise "Experimental Farm "Elitne" of V.Y.Yuriev Plant Production Institute of NAAS of Ukraine.

| Sowing period | Variety | Caterpillars which were detected, specimens/100 plants | | |
|---------------------|----------|--|------|------|
| | | 2018 | 2019 | 2020 |
| III decade of April | Biliavka | 4 | 5 | 2 |

| | | | | |
|-------------------|-------------|-----|-----|-----|
| | Sprytna | 2 | 4 | 3 |
| | Malvina | 2 | 4 | 2 |
| Average | | 2.7 | 4.3 | 2.3 |
| | Biliavka | 4 | 2 | 5 |
| | Sprytna | 6 | 5 | 8 |
| | Malvina | 8 | 4 | 6 |
| | Annushka | 7 | 3 | 6 |
| | Korada | 3 | 5 | 2 |
| | Vyshyvanka | 6 | 2 | 5 |
| | Kobza | 8 | 6 | 11 |
| | Krasunia | 4 | 7 | 6 |
| | Baika | 6 | 3 | 7 |
| | Perlyna | 9 | 5 | 11 |
| II decade of May | Raiduga | 2 | 5 | 10 |
| | Melodiia | 4 | 9 | 8 |
| | Pysanka | 10 | 7 | 11 |
| | Sloboda | 6 | 4 | 8 |
| | Aleksandryt | 7 | 5 | 9 |
| | ESC Senator | 8 | 4 | 2 |
| | ES Mentor | 2 | 2 | 4 |
| | Aligator | 6 | 2 | 5 |
| | Syverka | 1 | 8 | 7 |
| | Adamos | 6 | 7 | 10 |
| | Muza | 11 | 5 | 9 |
| Average | | 5.9 | 4.8 | 7.1 |
| | Biliavka | 25 | 10 | 15 |
| III decade of May | Sprytna | 21 | 11 | 21 |
| | Malvina | 29 | 15 | 18 |
| average | | 25 | 12 | 18 |

Table 2. Percentage of damaged beans in the State Enterprise "Experimental Farm "Elitne" of V.Y.Yuriev Plant Production Institute of NAAS of Ukraine Kharkiv district, Kharkiv region (July 2018).

| Sowing period | Variety | In total, for 100 plants | Beans (pieces) | | % |
|---------------------|------------|--------------------------|----------------|---------|------|
| | | | Intact | Damaged | |
| III decade of April | Biliavka | 2431 | 2417 | 14 | 0.6 |
| | Sprytna | 3053 | 3045 | 8 | 0.3 |
| | Malvina | 3294 | 3276 | 18 | 0.5 |
| average | | 2926 | 2912.7 | 13.3 | 0.47 |
| II decade of May | Biliavka | 2362 | 2321 | 41 | 1.8 |
| | Sprytna | 3178 | 3134 | 35 | 1.1 |
| | Malvina | 3201 | 3162 | 39 | 1.2 |
| | Annushka | 2698 | 2671 | 27 | 1.0 |
| | Korada | 3402 | 3380 | 22 | 0.7 |
| | Vyshyvanka | 2987 | 2944 | 43 | 1.5 |
| | Kobza | 2604 | 2573 | 31 | 1.2 |
| | Krasunia | 2341 | 2298 | 43 | 1.9 |
| | Baika | 3201 | 3164 | 37 | 1.2 |
| | Perlyna | 2571 | 2541 | 30 | 1.2 |
| | Raiduga | 2385 | 2340 | 45 | 1.9 |
| | Melodiia | 2434 | 2402 | 32 | 1.3 |
| | Pysanka | 2806 | 2777 | 29 | 1.0 |
| | Sloboda | 2453 | 2421 | 32 | 1.3 |
| Aleksandryt | 3069 | 3050 | 19 | 0.6 | |
| ESC Senator | 3283 | 3267 | 16 | 0.5 | |
| ES Mentor | 3207 | 3187 | 20 | 0.6 | |

| | | | | | |
|-------------------|----------|--------|------|------|-----|
| | Aligator | 3531 | 3518 | 13 | 0.4 |
| | Syverka | 2809 | 2770 | 39 | 1.4 |
| | Adamos | 2411 | 2386 | 25 | 1.0 |
| | Muza | 2734 | 2703 | 31 | 1.1 |
| Average | | 2841.3 | 2810 | 30.9 | 1.1 |
| | Biliavka | 2632 | 2537 | 95 | 3.7 |
| III decade of May | Sprytina | 2598 | 2529 | 69 | 2.7 |
| | Malvina | 2842 | 2770 | 72 | 2.6 |
| Average | | 2690.7 | 2612 | 78.7 | 3.0 |

Table 3. Percentage of damaged beans by pea pod borer caterpillars in the State Enterprise "Experimental Farm "Elitne" of V.Y.Yuriev Plant Production Institute of NAAS of Ukraine Kharkiv district, Kharkiv region (July 2019).

| Sowing period | Variety | In total, for 100 plants | Beans (pieces) | | % |
|---------------------|-------------|--------------------------|----------------|---------|-----|
| | | | Intact | Damaged | |
| III decade of April | Biliavka | 2541 | 2536 | 5 | 0.2 |
| | Sprytina | 2980 | 2973 | 7 | 0.2 |
| | Malvina | 3240 | 3231 | 9 | 0.3 |
| Average | | 2920.3 | 2913.3 | 7 | 0.2 |
| II decade of May | Biliavka | 2602 | 2591 | 11 | 0.4 |
| | Sprytina | 3161 | 3148 | 13 | 0.4 |
| | Malvina | 2945 | 2930 | 15 | 0.5 |
| | Annushka | 2807 | 2789 | 18 | 0.6 |
| | Korada | 3575 | 3563 | 21 | 0.6 |
| | Vyshyvanka | 2958 | 2943 | 15 | 0.5 |
| | Kobza | 2680 | 2661 | 19 | 0.7 |
| | Krasunia | 2374 | 2352 | 22 | 0.9 |
| | Baika | 3423 | 3406 | 17 | 0.5 |
| | Perlyna | 2769 | 2749 | 20 | 0.7 |
| | Raiduga | 2478 | 2465 | 13 | 0.5 |
| | Melodiia | 2595 | 2577 | 18 | 0.7 |
| | Pysanka | 2759 | 2735 | 24 | 0.9 |
| | Sloboda | 2464 | 2443 | 21 | 0.9 |
| | Aleksandryt | 3093 | 3083 | 10 | 0.3 |
| | ESC Senator | 3283 | 3270 | 13 | 0.4 |
| | ES Mentor | 3342 | 3334 | 8 | 0.2 |
| | Aligator | 3567 | 3548 | 19 | 0.5 |
| | Syverka | 2669 | 2648 | 21 | 0.8 |
| | Adamos | 2517 | 2494 | 23 | 0.9 |
| Muza | 2763 | 2748 | 15 | 0.5 | |
| Average | | 2896.4 | 2880 | 17 | 0.6 |
| III decade of May | Biliavka | 2627 | 2605 | 22 | 0.8 |
| | Sprytina | 2692 | 2674 | 18 | 0.7 |
| | Malvina | 2864 | 2840 | 24 | 0.8 |
| Average | | 2727.7 | 2706.3 | 21.3 | 0.8 |

The number of damaged beans per 100 plants in the first sowing period (III decade of April) ranged from 8 to 18 pieces/100 plants in the Sprytina and Malvina varieties, respectively; in the second sowing period (II decade of May), 13 pieces/100 plants (Aligator) to 45 pieces/100 plants (Raduga) were damaged; in the III period (III decade of May), from 69 pieces/100 plants (Sprytina) to 95 pieces/100 plants (Biliavka) were damaged. The lowest percentage of damage to beans was observed in the first sowing period, 0.3% (Sprytina), the highest, 3.7% (Biliavka), in the third sowing period.

According to Table 3, in the first sowing period (III decade of April), the number of beans per 100 plants reached from 2541 pieces/100 plants on the Biliavka variety to 3240 pieces/100 plants on the Malvina variety; in the second sowing period (II decade of May), reached from 2374 pieces/100 plants on the Krasunia variety to 3575 pieces/100 plants on the Korada variety; in the third period (III decade of May), the number of beans per 100 plants was from 2627 pieces/100 plants on the Biliavka variety to 2864 pieces/100 plants on Malvina variety.

The number of damaged beans per 100 plants in the first sowing period (III decade of April) was from 5 to 9 pieces in the Sprytyna and Malvina varieties, respectively; in the second sowing period (II decade of May), 11 pieces/100 plants (Biliavka) to 24 pieces/100 plants (Pysanka) were damaged; in the third period (III decade of May), from 18 pieces/100 plants (Sprytyna) to 24 pieces/100 plants (Malvina) were damaged. The lowest percentage of damage to beans was observed in the first sowing period-0.3% (Malvina), the highest-0.8% (Biliavka and Malvina) in the third sowing period.

The number of damaged beans per 100 plants in the first sowing period (III decade of April) ranged from 18 to 29 pieces in the Sprytyna and Biliavka varieties, respectively; in the second sowing period (II decade of May), 12 pieces/100 plants (ESC Senator) to 51 pieces/100 plants (Vyshyvanka) were damaged; in the third period (III decade of May), 36 pieces/100 plants (Biliavka) to 45 pieces/100 plants (Malvina) were damaged. The lowest percentage of damage to beans was observed in the first sowing period of 0.6% (Malvina and Sprytyna), the highest at 1.5% (Sprytyna and Malvina) in the third sowing period.

Table 4. Percentage of damaged beans by pea pod borer caterpillars in the State Enterprise "Experimental Farm "Elitne" of V.Y.Yuriev Plant Production Institute of NAAS of Ukraine Kharkiv district, Kharkiv region (July 2020).

| Sowing period | Variety | In total, for 100 plants | Beans (pieces) | | % |
|---------------------|-------------|--------------------------|----------------|---------|-----|
| | | | Intact | Damaged | |
| III decade of April | Biliavka | 2612 | 2568 | 29 | 1.1 |
| | Sprytyna | 3197 | 3166 | 18 | 0.6 |
| | Malvina | 3473 | 3434 | 20 | 0.6 |
| Average | | 3094 | 3056 | 22.3 | 0.8 |
| II decade of May | Biliavka | 2595 | 2556 | 39 | 1.5 |
| | Sprytyna | 3294 | 3251 | 43 | 1.3 |
| | Malvina | 3053 | 3013 | 40 | 1.3 |
| | Annushka | 2768 | 2739 | 29 | 1.1 |
| | Korada | 3762 | 3725 | 37 | 1.0 |
| | Vyshyvanka | 3027 | 2976 | 51 | 1.7 |
| | Kobza | 2721 | 2683 | 38 | 1.4 |
| | Krasunia | 2430 | 2388 | 42 | 1.8 |
| | Baika | 3526 | 3479 | 47 | 1.4 |
| | Perlyna | 2629 | 2593 | 36 | 1.4 |
| | Raiduga | 2437 | 2396 | 41 | 1.7 |
| | Melodiia | 2584 | 2545 | 39 | 1.5 |
| | Pysanka | 2881 | 2846 | 35 | 1.2 |
| | Sloboda | 2523 | 2496 | 27 | 1.1 |
| | Aleksandryt | 3150 | 3129 | 21 | 0.7 |
| | ESC Senator | 3395 | 3383 | 12 | 0.4 |
| | ES Mentor | 3392 | 3377 | 15 | 0.4 |
| | Aligator | 3664 | 3646 | 18 | 0.5 |
| | Syverka | 2731 | 2697 | 34 | 1.3 |
| | Adamos | 2562 | 2533 | 29 | 1.1 |
| Muza | 2820 | 2783 | 37 | 1.3 | |
| Average | | 2949.7 | 2915.9 | 33.8 | 1.2 |
| III decade of May | Biliavka | 2764 | 2728 | 36 | 1.3 |
| | Sprytyna | 2681 | 2642 | 39 | 1.5 |
| | Malvina | 2983 | 2938 | 45 | 1.5 |
| Average | | 2809.3 | 2789.0 | 40.0 | 1.4 |

Table 5. Percentage of damaged seeds by pea pod borer caterpillars in the State Enterprise "Experimental Farm "Elitne" of V.Y.Yuriev Plant Production Institute of NAAS of Ukraine Kharkiv district, Kharkiv region (July 2018).

| Sowing period | Variety | In total, for 100 plants | Seeds (pieces) | | % |
|---------------------|----------|--------------------------|----------------|---------|-----|
| | | | Intact | Damaged | |
| III decade of April | Biliavka | 4851 | 4826 | 25 | 0.5 |
| | Sprytyna | 6101 | 6087 | 14 | 0.2 |
| | Malvina | 6498 | 6465 | 33 | 0.5 |
| average | | 5816.7 | 5792.7 | 24 | 0.4 |

| | | | | | |
|-------------------|-------------|--------|--------|-------|-----|
| | Biliavka | 4724 | 4649 | 75 | 1.6 |
| | Sprytyna | 6312 | 6245 | 67 | 1.1 |
| | Malvina | 6385 | 6311 | 74 | 1.2 |
| | Annushka | 5321 | 5273 | 48 | 0.9 |
| | Korada | 6772 | 6733 | 39 | 0.6 |
| | Vyshyvanka | 5935 | 5854 | 81 | 1.4 |
| | Kobza | 5176 | 5120 | 56 | 1.1 |
| | Krasunia | 4602 | 4523 | 79 | 1.7 |
| | Baika | 6365 | 6297 | 68 | 1.1 |
| | Perlyna | 5142 | 5087 | 55 | 1.1 |
| II decade of May | Raiduga | 4745 | 4662 | 83 | 1.8 |
| | Melodiia | 4812 | 4755 | 57 | 1.2 |
| | Pysanka | 5602 | 5550 | 52 | 0.9 |
| | Sloboda | 4893 | 4838 | 55 | 1.1 |
| | Aleksandryt | 6101 | 6067 | 34 | 0.6 |
| | ESC Senator | 6522 | 6494 | 28 | 0.4 |
| | ES Mentor | 6386 | 6350 | 36 | 0.6 |
| | Aligator | 7014 | 6991 | 23 | 0.3 |
| | Syverka | 5603 | 5531 | 72 | 1.3 |
| | Adamos | 4812 | 4768 | 44 | 0.9 |
| | Muza | 5426 | 5370 | 56 | 1.0 |
| Average | | 5650 | 5593.7 | 56.3 | 1.0 |
| III decade of May | Biliavka | 5238 | 5067 | 171 | 3.4 |
| | Sprytyna | 5111 | 4987 | 124 | 2.5 |
| | Malvina | 5642 | 5510 | 132 | 2.4 |
| Average | | 5330.3 | 5188 | 142.3 | 2.8 |

To determine the percentage of seed damage during the growing season 2018-2020, we counted the number of seeds per plant and the number of intact and damaged seeds and calculated the percentage of damage. In total, there were 100 plants in each variety in the sample. The data are presented in Table 5.

According to Table 5, in the first sowing period (III decade of April), the number of seeds per 100 plants was from 4851 pieces (Biliavka) to 6498 pieces (Malvina). The percentage of damage ranged from 0.2% to 0.5%. In the second sowing period (II decade of May), the number of seeds per 100 plants reached 4724 pieces (Biliavka) to 7014 pieces in the Aligator variety. The percentage of damage ranged from 0.3% to 1.6%. In the third sowing period (III May decade), the number of seeds per 100 plants was from 5111 pieces (Sprytyna) to 5642 pieces (Malvina). The percentage of damage ranged from 2.4% to 3.4%.

According to Table 6, in the first sowing period (III decade of April), the number of seeds per 100 plants ranged from 5093 pieces (Biliavka) to 6396 pieces (Malvina). The percentage of damage ranged from 0.1% to 0.3%; In the second sowing period (II decade of May), the number of seeds per 100 plants increased from 4726 pieces (Krasunia) to 7081 pieces on the Aligator variety. The percentage of damage ranged from 0.2% to 0.8%; in the third sowing period (III decade of May), the number of seeds per 100 plants increased from 5236 pieces (Biliavka) to 5638 pieces (Malvina). The percentage of damage ranged from 0.6% to 0.8%.

According to Table 7, in the first sowing period (III decade of April), the number of seeds per 100 plants ranged from 5,200 pieces (Biliavka) to 6,239 pieces (Malvina). The percentage of damage ranged from 0.6% to 1.1%; in the second sowing period (II decade of May), the number of seeds per 100 plants reached 4695 pieces (Krasunia) to 7345 pieces on the Korada variety. The percentage of damage ranged from 0.4% to 1.8%; In the third sowing period (III decade of May), the number of seeds per 100 plants was reached from 5275 pieces (Sprytyna) to 5806 pieces (Malvina). The percentage of damage ranged from 1.3% to 1.6%.

Table 6. Percentage of damaged seeds by pea pod borer caterpillars in the State Enterprise "Experimental Farm "Elitne" of V.Y.Yuriev Plant Production Institute of NAAS of Ukraine Kharkiv district, Kharkiv region (July 2019).

| Sowing period | Variety | Seeds (pieces) | | | % |
|---------------------|----------|--------------------------|--------|---------|-----|
| | | In total, for 100 plants | Intact | Damaged | |
| III decade of April | Biliavka | 5093 | 5084 | 9 | 0.1 |
| | Sprytyna | 5993 | 5981 | 12 | 0.2 |
| | Malvina | 6396 | 6380 | 16 | 0.3 |
| average | | 5827.3 | 5815 | 12.3 | 0.2 |
| II decade of May | Biliavka | 5228 | 5207 | 21 | 0.4 |
| | Sprytyna | 6281 | 6258 | 23 | 0.4 |
| | Malvina | 5870 | 5844 | 26 | 0.4 |

| | | | | | |
|-------------------|-------------|--------|--------|------|-----|
| | Annushka | 5579 | 5547 | 32 | 0.6 |
| | Korada | 7041 | 7004 | 37 | 0.5 |
| | Vyshyvanka | 5879 | 5851 | 28 | 0.5 |
| | Kobza | 5345 | 5310 | 35 | 0.7 |
| | Krasunia | 4726 | 4686 | 40 | 0.6 |
| | Baika | 6722 | 6693 | 29 | 0.4 |
| | Perlyna | 5504 | 5467 | 37 | 0.7 |
| | Raiduga | 4952 | 4929 | 23 | 0.5 |
| | Melodiia | 5162 | 5129 | 33 | 0.6 |
| | Pysanka | 5468 | 5426 | 42 | 0.7 |
| | Sloboda | 4923 | 4883 | 40 | 0.8 |
| | Aleksandryt | 6086 | 6068 | 18 | 0.3 |
| | ESC Senator | 6470 | 6446 | 24 | 0.4 |
| | ES Mentor | 6595 | 6580 | 15 | 0.2 |
| | Aligator | 7081 | 7046 | 35 | 0.5 |
| | Syverka | 5240 | 5201 | 39 | 0.7 |
| | Adamos | 4990 | 4948 | 42 | 0.8 |
| | Muza | 5440 | 5412 | 28 | 0.5 |
| Average | | 5742 | 5711.2 | 30.8 | 0.5 |
| | Biliavka | 5236 | 5195 | 41 | 0.8 |
| III decade of May | Sprytyna | 5345 | 5311 | 34 | 0.6 |
| | Malvina | 5638 | 5593 | 45 | 0.8 |
| Average | | 5406.3 | 5366.3 | 40 | 0.7 |

Table 7. Percentage of damaged seeds by pea pod borer caterpillars in the State Enterprise "Experimental Farm "Elitne" of V.Y.Yuriev Plant Production Institute of NAAS of Ukraine Kharkiv district, Kharkiv region (July 2020).

| Sowing period | Variety | In total, for 100 plants | Seeds (pieces) | | % |
|---------------------|-------------|--------------------------|----------------|---------|-----|
| | | | Intact | Damaged | |
| III decade of April | Biliavka | 5200 | 5141 | 58 | 1.1 |
| | Sprytyna | 6058 | 6022 | 36 | 0.6 |
| | Malvina | 6239 | 6199 | 40 | 0.6 |
| Average | | 5832.3 | 5787.3 | 44.7 | 0.8 |
| II decade of May | Biliavka | 5123 | 5045 | 78 | 1.5 |
| | Sprytyna | 6421 | 6335 | 86 | 1.4 |
| | Malvina | 6125 | 6045 | 80 | 1.3 |
| | Annushka | 5578 | 5520 | 58 | 1.1 |
| | Korada | 7345 | 7271 | 74 | 1.0 |
| | Vyshyvanka | 6041 | 5939 | 102 | 1.7 |
| | Kobza | 5226 | 5150 | 76 | 1.5 |
| | Krasunia | 4695 | 4611 | 84 | 1.8 |
| | Baika | 6980 | 6886 | 94 | 1.4 |
| | Perlyna | 5123 | 5051 | 72 | 1.4 |
| | Raiduga | 4860 | 4778 | 82 | 1.7 |
| | Melodiia | 5103 | 5025 | 78 | 1.6 |
| | Pysanka | 5648 | 5578 | 70 | 1.3 |
| | Sloboda | 5016 | 4962 | 54 | 1.1 |
| | Aleksandryt | 6186 | 6142 | 44 | 0.7 |
| | ESC Senator | 6593 | 6569 | 24 | 0.4 |
| | ES Mentor | 6603 | 6573 | 30 | 0.5 |
| | Aligator | 7125 | 7089 | 36 | 0.5 |
| | Syverka | 5382 | 5314 | 68 | 1.3 |
| | Adamos | 5086 | 5028 | 58 | 0.6 |
| Muza | 5586 | 5511 | 75 | 1.4 | |
| Average | | 5802.1 | 5734.4 | 67.8 | 1.2 |
| III decade of May | Biliavka | 5537 | 5465 | 72 | 1.3 |

| | | | | | |
|---------|---------|--------|--------|----|-----|
| | Sprytna | 5275 | 5197 | 78 | 1.5 |
| | Malvina | 5806 | 5716 | 90 | 1.6 |
| Average | | 5539.3 | 5459.3 | 80 | 1.5 |

In our study, experiments were conducted on seeds damaged by pea pod borer caterpillars under the laboratory conditions of the State Enterprise "Experimental Farm "Elitne" of V.Y.Yuriev Plant Production Institute of NAAS of Ukraine Kharkiv district, Kharkiv region. The seeds were analyzed for fat and protein content. The data are included in Table 8.

Table 8. Results of analysis of protein and oil content of soybean samples from the State Enterprise "Experimental Farm "Elitne" of V.Y.Yuriev Plant Production Institute of NAAS of Ukraine Kharkiv district, Kharkiv region in 2018-2020.

| Crop | The name of a sample | 2018 | | 2019 | | 2020 | | Average for 2018-2020 | |
|---------|----------------------|--------------------|----------------|--------------------|----------------|--------------------|----------------|-----------------------|----------------|
| | | Protein content, % | Oil content, % | Protein content, % | Oil content, % | Protein content, % | Oil content, % | Protein content, % | Oil content, % |
| Soybean | Undamaged I | 33.20 | 21.29 | 40.83 | 20.53 | 36.3 | 21.29 | 36.78 | 21.04 |
| | Undamaged II | 35.00 | 21.32 | 40.77 | 20.66 | 36.9 | 21.38 | 37.56 | 21.12 |
| | Undamaged III | 32.78 | 21.32 | 41.08 | 20.77 | 36.6 | 21.43 | 36.82 | 21.17 |
| | Average | 33.66 | 21.31 | 40.89 | 20.65 | 36.6 | 21.36 | 37.05 | 21.10 |
| | Damaged I | 35.72 | 20.36 | 41.00 | 18.96 | 38.4 | 20.20 | 38.37 | 19.84 |
| | Damaged II | 36.11 | 20.74 | 41.08 | 18.86 | 38.8 | 20.12 | 38.66 | 19.90 |
| | Damaged III | 36.14 | 19.80 | 41.13 | 18.80 | 39.1 | 19.96 | 39.09 | 19.52 |
| | Average | 35.99 | 20.3 | 41.07 | 18.87 | 38.76 | 20.09 | 38.61 | 19.75 |

According to Table 8, on average for 2018-2020, the following results were obtained: damaged seeds-38.61% of protein and 19.75% of oil; undamaged seeds-37.05% and 21.10% of oil.

During 2018-2020, soybean crops were monitored for pea pod borer caterpillars and the most colonized varieties were sprayed with insecticides. The obtained data are included in Tables 9, 10, 11.

According to Table 9, it can be seen that the most significant technical efficiency on the 3rd day was shown by the preparation Nurel D, 55% emulsion concentrate (1.0 l/ha)-28%, on the 7th day-Antigusin 50% suspension concentrate (0.15 l/ha)-59%, on the 14th day-preparation Koragen, 20% suspension concentrate (0.2 l/ha)-82%.

Table 9. Technical efficiency of insecticide application in protecting soybean from pea pod borer caterpillars at the State Enterprise "Experimental Farm "Elitne" of V.Y.Yuriev Plant Production Institute of NAAS of Ukraine Kharkiv district, Kharkiv region in 2018.

| Experiment variant | Pest population density (specimens/plant) before spraying and on the 3 rd , 7 th and 14 th day after spraying | | | | Technical efficiency of action (%) on the 3 rd , 7 th and 14 th days after spraying | | |
|--|--|------|------|------|--|----|----|
| | before | 3 | 7 | 14 | 3 | 7 | 14 |
| | Control H ₂ O | 0.29 | 0.24 | 0.27 | 0.32 | | |
| Koragen, 20% suspension concentrate (0.2 l/ha) | 0.29 | 0.24 | 0.14 | 0.05 | 17 | 51 | 82 |
| Nurel D, 55% emulsion concentrate (1.0 l/ha) | 0.29 | 0.21 | 0.18 | 0.10 | 28 | 38 | 66 |
| Chlorpyrivit-agro, 55% emulsion concentrate (1.0 l/ha) | 0.29 | 0.26 | 0.17 | 0.13 | 10 | 41 | 55 |
| Antigusin 50% suspension concentrate (0.15 l/ha) | 0.29 | 0.22 | 0.12 | 0.08 | 24 | 59 | 72 |
| SED05 | -- | 0.19 | 0.16 | 0.12 | -- | | |

Note: * SED - the most minor essential difference.

Table 10. Technical efficiency of insecticide application in protecting soybean from pea pod borer caterpillars at the State Enterprise "Experimental Farm "Elitne" of V.Y.Yuriev Plant Production Institute of NAAS of Ukraine Kharkiv district, Kharkiv region in 2019.

| Experiment variant | Pest population density (specimens/plant) before spraying and on the 3 rd , 7 th and 14 th day after spraying | | | | Technical efficiency of action (%) on the 3 rd , 7 th and 14 th days after spraying | | |
|--|--|------|------|------|--|----|----|
| | Before | 3 | 7 | 14 | 3 | 7 | 14 |
| Control H ₂ O | 0.15 | 0.16 | 0.18 | 0.18 | | | |
| Koragen, 20% suspension concentrate (0.2 l/ha) | 0.15 | 0.11 | 0.08 | 0.04 | 26 | 46 | 73 |
| Nurel D, 55% emulsion concentrate (1.0 l/ha) | 0.15 | 0.13 | 0.10 | 0.07 | 13 | 33 | 53 |
| Chlorpyrivit-agro, 55% emulsion concentrate (1.0 l/ha) | 0.15 | 0.11 | 0.08 | 0.06 | 26 | 46 | 60 |
| Antigusin 50% suspension concentrate (0.15 l/ha) | 0.15 | 0.10 | 0.07 | 0.05 | 33 | 53 | 66 |
| SED05 | -- | 0.09 | 0.09 | 0.10 | -- | | |

Note: * SED - the most minor essential difference.

According to table 10 the best technical efficiency on the 3rd was shown by preparation Antigusin 50% suspension concentrate (0.15 l/ha)-33%, on the 7th day-also preparation Antigusin 50% suspension concentrate (0.15 l/ha)-53%, on the 14th day-preparation Koragen, 20% suspension concentrate (0.2 l/ha)-73%.

Table 11. Technical efficiency of insecticide application in protecting soybean from pea pod borer caterpillars at the State Enterprise "Experimental Farm "Elitne" of V.Y.Yuriev Plant Production Institute of NAAS of Ukraine Kharkiv district, Kharkiv region in 2020.

| Experiment variant | Pest population density (specimens/plant) before spraying and on the 3 rd , 7 th and 14 th day after spraying | | | | Technical efficiency of action (%) on the 3 rd , 7 th and 14 th days after spraying | | |
|--|--|------|------|------|--|----|----|
| | Before | 3 | 7 | 14 | 3 | 7 | 14 |
| Control H ₂ O | 0.21 | 0.18 | 0.20 | 0.24 | - | - | - |
| Koragen, 20% suspension concentrate (0.2 l/ha) | 0.21 | 0.18 | 0.14 | 0.04 | 14 | 33 | 81 |
| Nurel D, 55% emulsion concentrate (1.0 l/ha) | 0.21 | 0.17 | 0.13 | 0.08 | 19 | 38 | 62 |
| Chlorpyrivit-agro, 55% emulsion concentrate (1.0 l/ha) | 0.21 | 0.15 | 0.11 | 0.06 | 29 | 47 | 71 |
| Antigusin 50% suspension concentrate (0.15 l/ha) | 0.21 | 0.17 | 0.10 | 0.07 | 19 | 52 | 67 |
| SED05 | -- | 0.14 | 0.08 | 0.08 | -- | | |

Note: * SED-the smallest essential difference.

According to Table 11 the best technical efficiency on day 3 was shown by preparation Chlorpyrivit-agro, 55% emulsion concentrate (1.0 l/ha) -29%, on day 7 Antigusin preparation, 50% suspension concentrate (0.15 l/ha)-52%, on day 14 Koragen preparation, 20% suspension concentrate (0.2 l/ha)-81%.

Conclusion

According to the data of the experiments, it can be concluded that the soybean plants that were sown in the third decade of May and reached the grain filling phase were the most damaged. The number of caterpillars in soybean plants in 2018 ranged from 2 to 29 specimens/100 plants, in 2019-from 2 to 22 specimens/ 100 plants, in 2020-from 2 to 21 specimens/100 plants. When soybean plants were examined, the damage was also found to beans and seeds. In 2018, the percentage of damage ranged from 0.3% to 3.7%, in 2019 from 0.2% to 0.9%, and in 2020 from 0.6% to 1.8%. The percentage of damaged seeds was: in 2018-from 0.2% to 3.4%, in 2019-from 0.1% to 0.8%, and in 2020-from 0.6% to 1.8%. Analysis of seeds for oil and protein content showed that when seeds are damaged by pea pod borer, the oil content is greatly reduced and is a significant indicator of soybean seed quality. With the massive damage to beans caused by this pest, it can be lost 70-80% of the yield (depending on the sowing period, even up to 90%). During 2018-2020, soybean crops were monitored for pea pod borer caterpillars and the most colonized varieties were sprayed with insecticides. In 2018, the highest technical efficiency was shown on the third day by the preparation of Nurel D, 55%

emulsion concentrate (1.0 l/ha)-28%, on the 7th day-Antigusin 50% suspension concentrate (0.15 l/ha)-59%, on the 14th day-preparation Koragen, 20% suspension concentrate (0.2 l/ha)-82%. In 2019, the best technical efficiency on the third day was shown by preparation of Antigusin 50% suspension concentrate (0.15 l/ha)-33%, on the seventh day-also preparation of Antigusin 50% suspension concentrate (0.15 l/ha)-53%, on the 14th day-Preparation Koragen, 20% suspension concentrate (0.2 l/ha)-73%. In 2020, the best technical efficiency on day 3 was shown by Chlorpyrivit-agro preparation, 55% emulsion concentrate (1.0 l/ha)-29%, on day 7 Antigusin 50% suspension concentrate (0.15 l/ha)-52%, on day 14 Koragen preparation, 20% suspension concentrate (0.2 l/ha)-81%.

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