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Damages in wheat varieties caused by cereal leaf beetle (*Oulema melanopus* L.) under treatment by insecticides

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Abstract

Cereal leaf beetle – CLB (*Oulema melanopa* L.), both adults and larvae cause significant damage leaves of wheat, which can be reduced by the use of insecticides to control the pest. The aim of this work was study of damage flag leaf in wheat varieties caused by cereal leaf beetle and efficiency of insecticide applayd for plant protection wheat against CLB. The three varieties of wheat: Zemunska Rosa, Aurelia, and Belija, were used for the study in a field designed in three repetitions with entomological cages with an area of 1 m^2. The experiment caried out on field condition in Maize Research Institute, Belgrade. The damage assessment was carried out on the flag leaf area in plant population of wheat. Results of study showed significant differences in number of damaged plants in entomological cages in comparison to outside the entomological cages (open field). In entomological cages the lowest number of damaged plants was on treatment with insecticide deltamethrin in variety Aurelia (4.05%), and the highest was on control variant (without insecticide application) in variety Belija (28.45%). In crops outside the entomological cages, the cereal leaf beetle attacks caused the lowest number of damaged plants on treatment with insecticide deltamethrin in variety Zemunska Roda (8.833%) and the highest was on control variant (without insecticide application) in variety Belija (26.53%). In average for all three variery and all treatments, in entomological cages was lower number of damaged plant (11.31%), than outside the entomological cages 15.21%. Obtained valuese of damaged plants are significantly different. On the base of result established that number of damages plants was different among analyzed varieties on each treatment and that insecticide deltamethrin had the highest efficiency in protection plant damages against the cereal leaf beetle.

Key words: cereal leaf beetle, insecticide, wheat, damage, variety

INTRODUCTION

Wheat (*Triticum aestivum* L.) stands as the predominant plant species utilized in global dietary consumption among all cereals. It serves as a vital reservoir of essential nutrients, including proteins, carbohydrates, fats, vitamins, and micronutrients (Knežević et al., 2022). The progression of scientific inquiry has significantly propelled advancements within agricultural production. This evolution is characterized by the introduction of novel varieties and hybrids, refinement of cultivation methodologies, and the continuous enhancement of mechanisms aimed at safeguarding plant species against prevalent diseases and pestilent threats (Knežević et al., 2020). Notably, among the array of biotic stressors, insects wield substantial influence over the physiological development, productivity, and qualitative attributes of plants (Farook et al., 2018).

The cereal leaf beetle (*Oulema melanopus* L.) is one of the most economically significant pests of small grains in the agro-ecological circumstances of the Republic of Serbia, as well as of all bigger grain fields in Europe and North America. As a pest, cereal leaf beetle mostly feeds on wheat, oats, and barley, while they can also attack other minor grains (Steinger, 2020). Adult insects typically measure between 4-6 mm in length, exhibiting a dark to dark-blue hue with orange appendages and thoracic region. According to Maceljski (2004), the peak abundance of adults often occurs around mid-April in the agro-ecological conditions of the Republic of Serbia. Usually approximately 5 mm long, the larva is pale yellow in colour and coated with excrement-containing mucus, which can give it a black hue. At their last larval stage (4th stage), they may grow up to 8 mm in length. The life of the cereal leaf beetles imago varies from 10 to 90 days, with an average of 40 to 50 days, depending on the external climatic conditions, particularly the air temperature (Philips et al., 2011). Cereal leaf beetle overwinters as an adult. on weedy plants or plant remnants left in the soil (Ulrich et al., 2004).

Larvae of *O. melanopus* feed on leaf tissue, resulting in yield losses from 5 to 20% in small grain crops (Deutsch et al., 2018; Mazurkiewicz et al., 2021). This pest is classified among those causing significant agricultural damage in Europe and the USA (Samková et al., 2020). Prominently, seed yield reductions have been observed to be particularly pronounced in spring wheat, reaching up to 49% (Konyspaevna, 2012), and in barley, where reductions of up to 75% have been recorded (Dimitrijević et al., 2001). Research conducted in Hungary has underscored the variability in plant damage, contingent upon factors such as genotype, seasonal conditions, and geographical location (Császár et al., 2021). Studies in the Republic of Serbia have shown that cereal leaf beetles cause damage ranging from 2 to 30% in wheat and other small grains crops (Ćirić et al., 1993; Stamenković, 2004), with the highest damage (up to 70%) caused by fourth-stage larvae (Milovac and Franeta, 2016).

The aim of this work was study of damage flag leaf in wheat varieties caused by cereal leaf beetle, and efficiency of insecticide applied for wheat protection against cereal leaf beetle.

MATERIALS AND METHODS

The study was conducted on experimental field of Maize Research Institutr, Belgrade in 2018 and 2019. The three winter wheat varieties (Zemunska rosa, Aurelia, and Belija), and two insecticides from the pyrethroid family (deltamethrin and bifenthrin) were included in experimental study. Wheat varieties were sown with a seeder in rows with a distance of 0.25 m on a plot 1 m wide and 15 m long in three replications. On the sown area of three wheat variety, an experiment was designed on open field three plots 1.0 m^2 in three replications in total 65 square meters (one plot for control -without insecticide application, and for two treatments by insecticides) and other experiment for three wheat varieties with the installation of three entomological cages (1.0 m x 1.0 m x 1.5 m, control, and two treatments with insecticides) in three replications i.e. total 27 entomological cages (Figure 1).

Figure 1. Appearance of entomological cages in the field and their installation (original)

Entomological cages installed a few weeks after seed germination and plant sprouting and closed during vegetation period. The cereal leaf beetle overwinters in the soil as an imago; thus, it was predicted that it would appear within the cage following the prompt installation of the cage in the field prior to the rise in the average daily temperature. Opening of the cages was conducted exclusively during insecticidal treatment against cereal leaf beetles (for treated cages), while control cages remained unopened except during damage assessment.

Throughout the vegetative phase, foliar applications of insecticides containing chemically active compounds: chemical preparation Decis 2,5 EC - deltamethrin (25 g l^{-1}) and Fobos EC - bifenthrin (100 ml ha^{-1}), were applicated to the cereal crops. The preparations were applied in a concentration of 0.1-0.15 l/ha (1-1.5 ml/100 m²) by treatment at the appearance of larvae of the third stage of development, only once in the examined years. The application of insecticides was conducted by using a backpack motor sprayer-atomizer model Villager DM 14 PE.

After the emergence of the plants, the composition of the plants per square meter was determined by counting individual plants. Later in the growing season, the assessment included visual inspection of a designated area of one square meter and counting of damaged plants. Based on the total number of plants per unit area and the number of attacked plants (attack on the flag leaf), we determined the percentage of cereal leaf beetle attacks. This was done both for plants in entomological cages and for plants in the open field.

SPSS Statistics 20 (trial version) was used for mathematical-statistical data processing (Pallant, 2007). The LSD test was used to evaluate the significant differences between the average results.

RESULTS AND DISCUSSION

In all three wheat varieties in entomological cages and outside of them, all treatments with insecticides and all vareties, variations in the number of plants with damage to the leaf surface (flagellar) from the attack of cereal leaf beetle (*O. melanopus*) was found. The number of damaged plants varied, where the lowest was 4.05% in the variety Aurelia treated with an insecticide based on deltamethrin in plants that were in entomological cages, and the highest was 28.45% in the variety Belija in the control also in plants in entomological cages (Table 1). In the case of wheat varieties that were in the open field, the number of plants with leaf damage from cereal leaf beetle attacks was the highest in the Belija variety on the control variant (26.53%), while the lowest attack was in the Zemunska Rosa variety in the treatment insecticide with the active substance deltamethrin (8.83%) (Table 1).

Table 1. Variation in flag leaf damage caused by *O. melanopus* in wheat

No.	Vareties	Treatment	Plants in cages		Plants in open field		Average	
			$\bar{X}$ (%)	CV (%)	$\bar{X}$ (%)	CV (%)	$\bar{X}$ (%)	CV (%)
1.	Zemunska Rosa	Control	15.51^{c}	26.60	18.91^{c}	6.78	17.21^{b}	19.21
		Deltamethrin	6.31^{ef}	12.00	8.83^{f}	26.09	7.57^{e}	21.26
		Bifenthrin	5.66^{fg}	19.88	10.06^{f}	14.16	7.86^{e}	33.99
2.	Aurelia	Control	20.13^{b}	15.84	15.42^{d}	13.74	17.78^{b}	19.91
		Deltamethrin	4.05^{g}	29.47	8.65^{f}	22.77	6.35^{e}	35.87
		Bifenthrin	5.77^{efg}	6.59	15.67^{d}	6.59	10.72^{d}	41.85
3.	Belija	Control	28.45^{a}	18.20	26.53^{a}	23.05	27.49^{a}	18.83
		Deltamethrin	8.33^{d}	4.24	12.03^{e}	30.74	10.18^{d}	30.50
		Bifenthrin	7.63^{de}	25.91	20.83^{b}	11.37	14.23^{c}	42.61
Average			11.31	30.78	15.21	30.06	13.26	38.05

In Table 1, lowercase letters above the percentage of plants damaged by larvae *O. melanopus* indicate whether there was a statistically significant difference between treatments ($p<0.05$) - the same letters indicate no statistically significant difference, including and comparing all treatments and all three vareties.

Among the studied wheat vareties, the total percentage of plants damaged by larvae *O. melanopus* was highly significantly greater ($p<0.01$) in the control varieties than in the treatments with insecticides.

In all three varieties of wheat in entomological cages, the number of plants with damaged flag leaf area on the control variant was highly significantly higher ($p<0.01$) than in the treatments with bifenthrin and deltamethrin. The same was found for the plants that were in the open field, with only one exception in the case of the Aurelia variety, where the plants outside the cage treated with the active substance bifenthrin had a slightly higher (15.67%) attack than the control plants (15.42%).

The coefficient of variability (CV%) for flag leaves area damage to wheat was the lowest in the variety Aurelia treated with deltamethrin (CV=4.05%) in caged plants, while the coefficient of variability was the highest in the variety Belija treated with deltamethrin (CV=30, 74%) in plants that were outside the cage.

Based on the number of plants with flag leaf area damage, wheat varieties varied slightly more in plants that were in cages (CV=30.78%), compared to plants in the open field (CV=30.06%) (Table 1).

In comparison of flag leaves area damage in wheat it was found that the plants in the open field had on average a highly significantly higher ($p<0.01$) percentage of attacked plants (15.21%) compared to the plants that were in the entomological cages (11.31%). The exceptions was that in entomological cages was higher damage of flag leaf area on control variant in the variety Aurelia (20.13%) than outside of cage (15.42%) and in the variety Belija (28.45% vs. 26.53%). In all other treatments, plants in cages had a less damages. The biggest differences were found in the treatments with the insecticide bifenthrin, where the attack was very different in all three varieties of wheat. In the Zemunska Rosa variety, on plants in cages, the treatment with bifenthrin had 5.66% of attacked plants, while plants outside the cage with this same treatment had 10.06% of attacks. In the comparison of the other two varieties, the differences were even greater: Aurelia from 5.77% to 15.67%; and Belija with the biggest differences where the attack jumped from 7.63% in caged plants to 20.83% in plants outside entomological cages.

In comparing treatments by insecticide, it is found that the plants treated with the deltamethrin insecticide on average had a lower damaged plants compared to the bifenthrin treatment. On average for varieties, only the winter variety Zemunska Rosa had a slightly lower percentage of damaged plants in the deltamethrin treatment (7.57%) compared to the bifenthrin treatment (7.86%). The other two varieties had a highly significantly lower ($p<0.01$) percentage of attacked plants in the deltamethrin treatment, namely the variety Aurelia: 6.35% in opposition to 10.72%, and Belija: 10.18% in opposition to 14.23%.

In comparing the varieties themselves, it is found the highest damage of flag leaves area in variety Belija on both treated and untreated plants. On average on the control variant in Belija had 27.49% of damaged plants, what is over the 10% higher than on control variant in Zemunska Rosa (17.21%) as well in Aurelia (17.78%). In the treatment with deltamethrin, the Belija variety had the highest average number of damaged plants, 10.18%, and significantly higher than the Zemunska Rosa variety (7.86%) and the Aurelija variety (6.35%). In the treatment with bifenthrin, on average, the highest number of damaged plants was in the variety Belija (14.23%), a smaller number in the variety Aurelia (10.72%) and the least in the variety Zemunska Rosa (7.86%). According to the number of damaged plants treated with the insecticide bifenthrin, significant differences were found between all three varieties of wheat (Table 1).

Analysis of variance shows that highly significant and significant differences ($p<0.01$, $p<0.05$) were observed for flagellar leaf damage between wheat varieties, between insecticide treatments, between caged and non-caged plants as well as in by variety/treatment, variety/cage, treatment/cage and variety/treatment/cage interactions (Table 2).

Table 2. Analysis of variance for the total percentage of flagellate leaves attacked by *O. melanopus* (Zemun Polje, 2020)

Source of variance	DF	Sum of Squares (SS)	Mean Square (MS)	F test	LSD 0,05	LSD 0,01
Genotype	2	444.308	222.154	28.759	1.8866	2.5297
Treatment	2	1619.023	809.511	104.797	1.8866	2.5297
Cage	1	205.218	205.218	26.567	1.5404	2.0655
G x T	4	124.328	31.082	4.024	3.2677	4.3816
G x C	2	8.154	4.077	0.528	2.6680	3.5776
T x C	2	236.856	118.428	15.331	2.6680	3.5776
G x T x C	4	105.207	26.302	3.405	4.6212	6.1966
Error	36	278.085	7.725			
Total	53	3021.179				

The use of insecticides produced the anticipated outcomes in our study, with all treated plants, whether they were in a cage or outside a cage, having substantially less ($p<0.01$) damage to their flag leaves area than the control. The variety Aurelia plants grown outside of cages are the sole exception, where the use of bifenthrin insecticide resulted in a little higher attack rate (15.67%) than the control group (15.42%). The research employed two chemicals that are part of the pyrethroid chemical group: deltamethrin and bifenthrin. These are synthetic versions of natural pyrethrins that are isolated from *Chrysanthemum cinerariaefolium* (Metcalf, 2000).

The efficiency of organophosphates, pyrethroids, neonicotins, and biological insecticides in lowering the population of *Ceutorhynchus obstrictus* in cabbage—a pest that is related to cereal leaf beetle —was examined by Cárcamo et al. (2005) in both an open field and a cage. Only two pyrethroids, deltamethrin and cyhalothrin-lambda, effectively decreased the density of *C. obstrictus* under field settings, even in areas where extremely high population levels were noted. The best results in controlling *O. melanopus* were obtained using pesticides belonging to the pyrethroid "family" (Philips et al., 2011; Reisig et al., 2012). Tanasković et al. (2012) found that, out of all the insecticides tested, two pyrethroids had the best efficacy in suppressing the *O. melanopus* population, with percentages of over 87 and 96%. Regarding the active ingredient bifenthrin, it showed unsatisfactory results when combined with a fungicide in the research conducted by Koch et al. (2005) to control *Cerotoma trifurcata* (Coleoptera).

CONCLUSIONS

In this investigation it was established significant differences between wheat varieties according to number of damaged plants caused by cereal leaf bettle and that the insecticide with the active substance deltamethrin has the best effect in suppressing of the cereal leaf beetle. In all three wheat varieties were established different number of damaged plants in entomological cages in comparison to outside the entomological cages (open field). In all three varieties on both insecticide treatment (deltamethrin and bifenthrin) and on control variant in Zemunska Rosa in entomological cages was established significan lower number of damaged plants than in outside the entomological cages, while in contrary in Aurelia and Belija was found higher number of damages plants by cereal leaf bettle in entomological cages than outside the entomological cages. The lowest number of damaged plants 4.05% was on the Aurelia variety in the cage on the treatment with insecticide deltamethrin, while the highest was on control variant (without insecticide application) in variety Belija (28.45%) in entomological cage, too. The outside the entomological cages, the lowest number of damaged plants (8.83%), caused by cereal leaf beetle attacks was on treatment with insecticide deltamethrin in variety Zemunska Roda, and the highest number of damaged plants (26.53%). was on control variant (without insecticide application) in variety Belija.

In average for all three treatments and all three wheat varieties the higher number of damaged plants (15.21%) was established in the outside the cages than in entomological cages (11.31%) damaged plants caused by cereal leaf beetle attack.

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