UDC 575. 633.15
https://doi.org/10.2298/GENSR2201289G
Original scientific article

INFLUENCE OF MAIZE HYBRIDS AND APPLAYED INSECTICIDES ON *Ostrinia nubilalis* HBN. ATTACK

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Grčak D., S. Gošić Dondo, M. Grčak, D. Ristić, D. Kondić, D. Hajder, Ž. Popović, D. Knežević (2022*). Influence of maize hybrids and applayed insecticides on Ostrinia nubilalis HBN. attack.* - Genetika, Vol 54, No.1, 289-306.

Ostrinia nubilalis Hbn. is a corn pest that can do great damage to plants in some seasons. The aim of this paper is to study the resistance / susceptibility of hybrids to the attack of European corn borer and the effects of different doses of insecticides and time of application in protection against pests on maize plants, but primarily the influence of hybrids on attack intensity. The six maize hybrids of different maturation groups (ZP 427, ZP 434, ZP 555, ZP 600, ZP 606 and ZP 666) used for study effect of attack of *Ostrinia nubillalis* Hbn., on control variant T1 without application of insecticide and on variant treated with two insecticides Fobos EC (bifentrin - 200 *ml* ha^{-1}) and combination of Match 050 EC and Nurelle D (lufenuron 50 g l^{-1} and hlorpirifos 500 g l^{-1} + cipermetrin 50 g l^{-1}), 0.75 l ha^{-1}) in two terms (in the first generation of insect flying T2 and T3 and in the second generation of insect flying T4 and T5) in three replication. The results showed the highest intensity of *Ostrinia nubilalis* Hbn. attack and degree of damages on control variant and significant differences between treatments for investigated parameters. Observing all hybrids and treatments, there was no statistical significance between the six examined maize hybrids of different maturity groups. In the control variant, the greatest attack (damage) was in plants, namely in the hybrid ZP 666 (94.28%) and ZP 606

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(93.90%) and among the variants of applied insecticides, the greatest damage was found in the treatment T5 with the applied combination of Match + Nurelle in hybrid ZP 555 and was 92.02%. On treatment T1-control variant without insecticides, the smallest attack with *Ostrinia nubilalis* Hbn. was found in the hybrid ZP 434 (from 88.76%) and among the variants of applied insecticides, the smallest attack was found on variant T2 with applied Phobos in the first generation of insect in hybrid ZP 434 and amounted to 77.12%. The attack of *Ostrinia nubilalis* Hbn. and variation of average mass of maize cob varied in dependence of maze of hybrids and variant of insecticides application.

Keywords: attack, hybrid, insecticide, maize, *Ostrinia nubilalis*

INTRODUCTION

The *Ostrinia nubilalis* Hbn. is one of the most dangerous pest of maize in Eastern Europe which can cause very high loss of grain yield (SZŐKE *et al*., 2002). The reduction of maze yield in Europe in early study variate from 2 to 25% (JOVANIĆ, 1969). In northern Europe, losses of approximately 8% of yield, but BOHN *et al*. (1999) found in Germany 25% of yield loss. In the central chernozem region of Russia the yield losses reached 15% in maize (SHPANEV *et al*. 2019). The intensity of attack of *Ostrinia nubilalis* varied from year to year depends of climatic condition (FROLOV and GRUSHEVAYA, 2020). In their study reported that European corn borer (ECB) population dynamics significantly related to environmental condition and that survival egg and larva depending from air temperature and air humidity during the last decade of May in the Krasnodar area, what confirmed earlier study which reported significant effect of weather conditions on ECB infestation in sweet maize (VELASCO *et al*., 2007; KESZTHELYI, 2010; MAIORANO, 2012; WALIGÓRA *et al*., 2014). The investigation of BAĞDATLI (2019) presented that attack of ECB related to technology growing and that this pest is higher in the conditions of intensive production and irrigation. For contoll European corn borer (ECB) (*Ostrinia nubilalis* Hübner, 1796) nawdays usualy can use chemical (insecticides) and biological (*Bacillus thuringiensis*) agents. Protecting corn crops from pests and reducing yields requires the application of pesticides, which increases production costs. In the USA, in 2010 year was estimated that the total annual cost (control costs and yield losses) of *Ostrinia nubilalis* has exceeded $1 billion (KORYCINSKA, 2010). Also, in Serbia and other European countries, Hungary, Italy, France, Spain, Germany etc. in maize production use insecticides. Mainly insecticides contains active ingredients are pyrethroids and organophosphates (MEISSLE *et al*., 2010).

In recent time in European Union prevail approach of integral protection, while biological measure of *Ostrinia nubilalis* control in area with high pressure of attack and lack of mechanization or insecticide application. Developing of genetically modified *Bt* maize genotype represent efficient alternative mode of control damages which can cause European corn borer attack. Actually, the genetic material of the bacterium *Bacillus thuringiensis var. kurstaki* was inserted into the corn, which produce a protein crystal, called delta endotoxins, that is toxic to insects and plants can make the protein in their cells. *Bt* is very selective and is only toxic to specific insects, which may help beneficial insects because *Bt* does not target them. Also, *Bt* has been found to be safe to all mammals, birds, and fish (BURKNESS *et al*., 2001).

In Serbian area, *Ostrinia nubilalis* had only one or two generations during the year, which means that it was a univoltine (one generation per year) or bivoltine (two generation per year) species. In the last few decades, the number of generations per year has increased significantly, so that now the corn borer has become a multivolt species. In the fields, the appearance of one winter and at least one summer generation has now been noticed. The number of summer generations varies on an annual basis, and mostly depends on seasonal fluctuations in temperature and rainfall (BAČA *et al*., 2007). In addition to the fact that corn borer causes direct damage to corn plants by causing physical injuries to the plant, it opens the way for infection with fungi of the genus *Fusarium spp*., which can cause even greater damage (BLANDINO *et al*., 2015; CZEMBOR, 2015; NEDĚLNÍK *et al*., 2012).

The aim of this work is study resistance / sensitivity of maize hybrids on *Ostrinia nubilalis* Hbn., attack and efficiency of different insecticides and term of insecticide aplication on *Ostrinia nubilalis* Hbn., attack on maize hybrids of different maturation groups and damage and protection of damage in maize.

MATERIAL AND METHODS

The investigation included six maize hybrids of different maturation groups (ZP 427, ZP 434, ZP 555, ZP 600, ZP 606 and ZP 666) and five variants maize hybrid treatment with insecticide application: T1 without insecticide and four variant of treatment: T2- with *Fobos* in the first generation of insect, T3 - with combination of *Match* and *Nurelle* in the first generation of insect, T4 - with *Fobos* in the second generation of insect and T5 - with combination of *Match* and *Nurelle* in the second generation of insect in three replication.

For treatments used insecticides Fobos EC (bifentrin, Galenika) in the amount of 200 ml ha^{-1} and combination of Match 050 EC (lufenuron 50 g l^{-1}) and Nurelle D (hlorpirifos 500 g l^{-1} and cipermetrin 50 g l^{-1}), 0,75 l ha^{-1}, which applied in two terms. The first term of foliar insecticide application was in June 26th – 15th days after the first-generation maximum flight (T2 and T3) in the first generation of insect and in the second generation of insect. The second time in July 28th -15 days after the second-generation maximum flight (T4 and T5).

The investigation carried out on the field of experiment of the Maize Research Institute “Zemun Polje” in Belgrade during 2018. The experiment was designed in three repetitions on a plot of 10.5 m². The sowing of maize hybrids was performed by machines in three rows of 5 m length with a distance between rows of 0.7 m and a distance between plants in a row of 0.25 m. The intensity of corn borer attack (*O. nubilalis*) was studied on six maize hybrids of different ripening groups.

In all plants, the intensity of attack of the European corn borer (*O. nubilalis*) was assessed according to the Hadžistević tolerance scale (HADŽISTEVIĆ, 1966). The treatment 15 days after maximum flight conducted according to recommendation (GOŠIĆ-DONDO *et al*., 2016); namely then the larvae is most vulnerable before they drill and insert in the plant.

In these analyzes, plants were used to assess damage from corn caterpillars, which are expressed in relative values and percentages.

Mathematical-statistical data processing was carried out using SPSS Statistics 20 (trial version software (PALLANT, 2007). The significant differences among the average values were estimated according to LSD test.

RESULTS

The investigation of intensity of the European corn borer attack during vegetation season of 2018 year showed that attack varied from the lowest value of 77.12% in hybrid ZP 434 on treatment T-2 with application of *Fobos* in the first generation of insect to the highest value at the ZP 666 (94.28%) on treatment T1- control variant without application of insecticide. Generally, in average the highest value of attack of the European corn borer was on treatment T1 – control (91.75%), while the lowest attack of the European corn borer in all six hybrids of maize was on treatment T2- with application of *Fobos* in the first generation of insect (81.54%). Its indicate more efficient effect of insecticide *Fobos* in protection from attack of European corn borer than effect of remain three variant of insecticide application. Also, in other variant of insecticide treatment characterized less intensity attack of European corn borer in tested hybrids of maize than on control variant (T1), Table 1.

Table 1. Total attack of Ostrinia nubilalis on plant of maize crop (%)

Maize hybrids	Treatments*					
	T1	T2	T3	T4	T5	Average
ZP 427	91.16 ± 3.44	82.90 ± 2.89	86.08 ± 7.12	83.30 ± 0.54	80.20 ± 2.99	84.728
ZP 434	88.76 ± 0.53	77.12 ± 1.82	80.71 ± 6.17	80.26 ± 2.98	84.60 ± 3.01	82.290
ZP 555	91.20 ± 0.57	83.00 ± 4.00	88.55 ± 0.64	83.80 ± 4.72	92.02 ± 5.75	87.714
ZP 600	91.18 ± 1.90	83.16 ± 1.56	81.89 ± 5.67	83.16 ± 2.20	80.87 ± 2.43	84.052
ZP 606	93.90 ± 2.19	81.87 ± 1.46	82.12 ± 5.98	84.33 ± 1.26	82.63 ± 2.99	84.970
ZP 666	94.28 ± 0.94	81.17 ± 1.71	83.12 ± 5.45	80.38 ± 5.36	80.99 ± 3.25	83.988
Average	91.746	81.536	83.745	82.538	83.551	84.623
F-test	F-value			P-value		
F-test for hybrids	1.3612			0.2522		
F-test for insecticides	8.5708			< 0.0001		
F-test for interaction	0.5431			0.9341		
LSD test	0.05			0.01		
LSD for hybrids	NS			NS		
LSD for insecticides	3.9439			5.2473		
LSD for interaction hybrids × insecticides	NS			NS		

*T1 = control variant, T2 = treated with *Fobos* in the first generation of insect, T3 = treated with combination of *Match* and *Nurelle* in the first generation of insect, T4 = treated with *Fobos* in the second generation of insect and T5 = treated with combination of *Match* and *Nurelle* in the second generation of insect. All values are presented as arithmetic mean ± standard error.

Observing all treatments, the best average results are found in the hybrid ZP 434 with a percentage average pest attack of 82.29%, while the worst was the hybrid ZP 555 with 87.71%. Other hybrids had an average percentage attack between 83.99 and 84.97%.

The attack intensity in treatment T2 - with application of *Fobos* in the first generation of insect was the lowest in hybrd ZP 434 (77.12%), while the highest value of attack was in hybrid ZP 600 (83.16%). On the treatment T3 - with applied combination of insecticide *Match* and *Nurelle* in the first generation of insect the lowest value of attack of European corn borer was found in maize hybrid ZP 434 (80.71%) while the highest attack was established in hybrid ZP 555 (88.55%). In the treatment T4 - with with application of *Fobos* in the second generation of insect the lowest value of attack of European corn borer was found in maize hybrid ZP 434 (80.26%) and the highest attack was in hybrid ZP 606 (84.33%). The attack intensity on treatment T5 - with application of combination of *Match* and *Nurelle* in the second generation of insect was the lowest in hybrd ZP 427 (80.20%) and the highest value of attack of European corn borer was in hybrid ZP 555 (92.02%), Table 1.

In the ZP 427 hybrid, the highest attack of European corn borer established on treatment T1 (91.16%) i.e. control variant (without application of insecticide) which was significantly higher than on tretment T3 (86.08% - with application combination of *Match* and *Nurelle* in the first generation of insect) and highly significant higher than on thretment T2 (82.90% - with application of *Fobos* in the first generation of insect), T4 (83.30% - with applied *Fobos* in the second generation of insect) and T5 (80.20% - with applicated combination of *Match* and *Nurelle* in the second generation of insect). The lowest value of attack of ECB was established on the treatment T5 (80.20% - with applicated combination of *Match* and *Nurelle* in the second generation of insect) which is highly significant lower than intensity attack on control variant T1 (91.16%) and tretment T3 (86.08% - with application combination of *Match* and *Nurelle* in the first generation of insect), while differences between values on treatment T2 (with application of *Fobos* in the first generation of insect) and on T4 (83.30% - with applied *Fobos* in the second generation of insect) were not significant (Table 1).

ZP 434 hybrids had the highest attack of European corn borer established on treatment T1 (88.76%) i.e. control variant (without application of insecticide) which was significantly higher than on tretment T5 (84.60% - with applicated combination of *Match* and *Nurelle* in the second generation of insect) and highly significant higher than on thretment T2 (77.12% - with application of *Fobos* in the first generation of insect), T3 (80.71% - with application combination of *Match* and *Nurelle* in the first generation of insect) and T4 (80.26% - with applied *Fobos* in the second generation of insect). The lowest value of attack of ECB was found on the treatment T2 (77.12% - with application of *Fobos* in the first generation of insect), which is highly significant lower than intensity attack on control variant T1 (88.76% - without insecticide application) and than on tretment T5 (84.60% - with applicated combination of *Match* and *Nurelle* in the second generation of insect) while differences between values on treatment T3 (80.71% - with application combination of *Match* and *Nurelle* in the first generation of insect) and on T4 (80.26% with applied *Fobos* in the second generation of insect) were not significant (Table 1).

The attack of ECB in ZP 555 was the highest (92.02%) on treatment T5 - with application combination of *Match* and *Nurelle* in the second generation of insect and on treatment T1 (91.20% - control variant -without application of insecticide) that were highly significant higher than on treatment T2 (83.00% - with application of *Fobos* in the first generation of insect) and T4 (83.30% - with applied *Fobos* in the second generation of insect). The lowest value of attack of ECB was found on the treatment T2 (83.00% - with application of *Fobos* in the first generation of insect), which was highly significant lower than intensity attack on control variant T1 (91.20% - without insecticide application), than on T3 (88.55% - with application combination of *Match* and *Nurelle* in the first generation of insect), and than on tretment T5 (92.02% - with application of combination of *Match* and *Nurelle* in the second generation of insect). The attack of ECB on treatment T4 (83.80% - with application of *Fobos* in the second generation of insect) was significant lower than on T3 (88.55% - with application combination of *Match* and *Nurelle* in the first generation of insect) while differences of value of ECB attack between T2 and T4 was not significant (Table 1).

In ZP 600 hybrids the highest attack of European corn borer established on treatment T1 (91.18%) i.e. control variant (without application of insecticide) which was highly significant higher than intensity attack on all remain variant of insecticide treatments: T2 (83.16% - with application of *Fobos* in the first generation of insect), T3 (81.89% - with application combination of *Match* and *Nurelle* in the first generation of insect), T4 (83.16% - with applied *Fobos* in the second generation of insect) and than on T5 (80.87% - with application of combination of *Match* and *Nurelle* in the second generation of insect). The lowest value of attack of ECB was found on the treatment T5 (80.87% - with application of combination of *Match* and *Nurelle* in the second generation of insect) but was not significantly different from intensity attack on remain three variant with application insecticides (T2 - 83.16%, T3 -81.89% and T4 - 83.16%), Table 1.

The intensity of attack of ECB at the ZP 606 was the highest on treatment T1 (93.90%) – control (without application of insecticide which was the highly significant higher than attack on all remain variant of insecticide treatments: T2 (81.87% - with application of *Fobos* in the first generation of insect), T3 (82.12% - with application combination of *Match* and *Nurelle* in the first generation of insect), T4 (84.33% - with applied *Fobos* in the second generation of insect) and than on T5 (82.639% - with application of combination of *Match* and *Nurelle* in the second generation of insect). The lowest value of attack of ECB was found on the treatment T2(81.87% - with application of *Fobos* in the first generation of insect) that was not significantly different from intensity attack on remain three variant with application insecticides (T3 - 82.12%, T4 - 84.33% and T5 - 82.63%), Table 1.

In ZP 666 hybrids the highest attack of ECB established on treatment T1 (94.28%) – control (without application of insecticide which was the highly significant higher than attack on all remain variant of insecticide treatments: T2 (81.17% - with application of *Fobos* in the first generation of insect), T3 (83.12% - with application combination of *Match* and *Nurelle* in the first generation of insect), T4 (80.38% - with applied *Fobos* in the second generation of insect) and than on T5 (80.99% - with application of combination of *Match* and *Nurelle* in the second generation of insect). The lowest value of attack of ECB was found on the treatment T4 (80.38% - with application of *Fobos* in the second generation of insect) although in comparison with values of ECB attack on the remain three variant with application of insecticides (T2 - 81.17%, T3 - 83.12% and T5 - 80.99%) differences was not significant (Table 1).

Table 2. Average weight of maize grain sample of ear (kg) and moisture in grain (%)

Maize hybrids	Sample weight (kg)	Cob weight (kg)	Grain moisture content (%)
ZP 427	1.63 ± 0.04	0.23 ± 0.010	12.97 ± 0.27
ZP 434	1.54 ± 0.03	0.19 ± 0.006	13.05 ± 0.67
ZP 555	1.83 ± 0.06	0.24 ± 0.011	16.62 ± 0.62
ZP 600	1.74 ± 0.05	0.22 ± 0.009	15.28 ± 0.34
ZP 606	1.90 ± 0.05	0.26 ± 0.008	16.80 ± 0.60
ZP 666	1.75 ± 0.10	0.25 ± 0.006	15.88 ± 0.57
F-value	4.8436	8.2776	10.6011
P-value	0.0033	0.0001	< 0.0001
LSD 0.05	0.1729	0.0249	1.5615
LSD 0.01	0.2344	0.3338	2.1161
LSD comparison	427 < 555, 606, 666 434 < 555, 600, 606, 666 600 < 606 > 666	606, 666 > 427, 434, 600 600, 606 > 555	427, 434 < 555, 600, 606, 666 555 > 600

*All values are presented as arithmetic mean ± standard error.

The intensity of the attack and the effect of the application of different insecticides influenced the degree of damage and the value of the analyzed traits in maize hybrids. The largest piston mass was found at ZP 606 (1.90 kg).

The highest average grain weight was in the hybrid ZP 606 (1.90 kg), which had the highest average weight of the cob (0.26 kg) and the highest moisture content in the grain (16.80%). Similarly, ZP 555 hybrids had high values of grain mass (1.83 kg), cob weight (0.24 kg) and grain moisture content (16.62%). The ZP 434 hybrid had the lowest grain weight (1.54 kg), which had both the lowest average cob weight (0.19 kg) and the lowest grain moisture content (12.94%) of Table 2.

Highly significant differences were found between maize hybrids for grain weight. The lowest grain mass had hybrid ZP 434 (1.54 kg) which was highly significant lower than grain mass in hybrid ZP 606 (1.90 kg) and then in ZP 555 (1.83 kg), and significantly lower than in ZP 600 (1.74 kg) and ZP 666 (1.75 kg). Also, the grain mass in ZP 427 (1.63 kg) was highly significant lower than in ZP 606 (1.90 kg) and significantly lower than in ZP 555 (1.83 kg), Table 2.

The mass of ear cob in hybrid ZP 434 (0.19 kg) was highly significant lower than in ZP 606 (0.26 kg), ZP 666 (0.25 kg), ZP 555 (0.24 kg) ZP 427 (0.23 kg), and significantly lower than in ZP 600 (0.22 kg), while the mass of corn cob in hybrid ZP 600 (0.22 kg) was significant lower than in ZP 606 (0.26 kg), ZP 666 (0.25 kg) and mass of corn cob in hybrid ZP 427 (0.23 kg), and significantly lower than in ZP 606 (0.26 kg), Table 2.

The moisture content in maize grain varied from a minimum of 12.94% in the ZP 434 hybrid to a maximum of 16.80% in the ZP 606 hybrid (Table 1). The grain moisture content in hybrid ZP 427 and ZP 434 (13.02% and 12.94%) had a significantly lower than in other hybrids ($p < .01$) while these two hybrids do not differ from each other in the percentage of moisture in the grain (Table 2).

Table 3. The total emergence of adults in maize (%)

Maize hybrids	Treatments*					
	T1	T2	T3	T4	T5	Average
ZP 427	91.67 ± 3.33	84.44 ± 1.11	85.00 ± 2.89	90.00 ± 2.89	87.22 ± 1.47	87.666
ZP 434	93.89 ± 1.11	90.00 ± 1.92	87.22 ± 1.47	87.78 ± 3.38	93.89 ± 0.56	90.556
ZP 555	88.33 ± 1.67	86.67 ± 5.09	92.22 ± 0.56	88.89 ± 5.47	88.33 ± 3.47	88.888
ZP 600	86.67 ± 3.47	82.78 ± 5.88	84.44 ± 3.64	85.00 ± 4.19	82.78 ± 7.47	84.334
ZP 606	90.00 ± 3.47	91.67 ± 1.67	92.22 ± 2.00	92.22 ± 0.56	90.00 ± 1.92	91.222
ZP 666	86.67 ± 6.31	85.56 ± 0.56	88.33 ± 1.67	91.11 ± 2.42	87.78 ± 2.22	87.890
Average	89.538	86.853	88.238	89.16	88.33	88.426
F-test	F-value		P-value			
F-test for hybrids	2.9735		0.0186			
F-test for insecticides	0.6360		0.6389			
F-test for interaction	0.5162		0.9484			
LSD test	0.05		0.01			
LSD for hybrids	4.0335		5.3666			
LSD for insecticides	NS		NS			
LSD for interaction hybrids × insecticides	NS		NS			

*T1 = control variant, T2 = treated with *Fobos* in the first generation of insect, T3 = treated with combination of *Match* and *Nurelle* in the first generation of insect, T4 = treated with *Fobos* in the second generation of insect and T5 = treated with combination of *Match* and *Nurelle* in the second generation of insect. All values are presented as arithmetic mean ± standard error.

The highest emergence of adults among all hybrids and treatments had ZP 434 (93.89%) on treatment T1 – on control variant (without application of insecticides) and on treatment T5 – application insecticides combination of *Match* and *Nurelle* (93.89%). Also, high emergence of adults was found in hybrid ZP 427 (91.67%) on control variant (without application of insecticides). The lowest value of emergence of adults was 82.78% in hybrid ZP 600 on treatment T2 – variant with application *Fobos* in the first generation of insect and T5 – with applied insecticide combination of *Match* and *Nurelle* (82,78%). In comparison each to other of all analyzed maize hybrids the lowest emergence of adults was found in ZP 600 at each treatment.

The emergence of adults on treatment T1 - on control variant in hybrid 434 (93.89%), was highly significant higher than in hybrids ZP 555 (88.33%), ZP 600 (86.67%) and ZP 666

(86.67%) while emergence of adults on hybrid ZP 427 (91.67%) was significantly higher than in hybrid ZP 600 (86.67%) and ZP 666 (86.67%).

On treatment T2 - with *Fobos* in the first generation of insect, the value of emergence of adults at the hybrid ZP 606 (91.67%) was highly significant higher than at the hybrid ZP 666 (85.56%), ZP 427 (84.44%), ZP 600 (82.78%) and significant higher than at the hybrid ZP 555 (86.67%). Also, emergence of adults at the hybrid ZP 434 (90.0%) was highly significant higher than in ZP 427 (84.44%), ZP 600 (82.78%).

The analysis of values of emergence of adults on treatment T3 - with combination of *Match* and *Nurelle* in the first generation of insect showed equal value of emergence of adults at hybrids ZP 555 (92.22%) and ZP 606 (92.22%) which was highly significant higher than at the ZP 427 (85.00%), ZP 600 (84.44%) and significantly higher than adults emergence at the hybrid ZP 434 (87.22%), while values of emergence of adults in remain maize hybrids were not significantly different.

The highest emergence of adults on treatment T4 - with applied *Fobos* in the second generation of insect was found at the ZP 606 (92.22%) which was highly significant higher than at the hybrid ZP 600 (85.00%) and significantly higher than at the hybrid ZP 434 (87.78%). Also, hybrid ZP 666 had emergence of adults 91.11% which was highly significan higher than adult emergence at the hybrid ZP 600 (85.00%) while values of emergence of adults in remain maize hybrids were not significantly different.

The value of emergence of adults in hybrid ZP 434 was the highest 93.89% on treatment T5 with applied combination of *Match* and *Nurelle* in the second generation of insect, which was highly significant higher than adult emergence at the ZP 555 (88.33%), ZP 666 (87.78%), ZP 427 (87.22%), ZP 600 (82.78%), and adult emergence in hybrid ZP 606 (90.00%) and ZP 555 (88.33%) was highly significant higher than emergence of adult in hybrid ZP 600 (82.78%). Also, emergence of adults in hybrids ZP (87.78%) and ZP 427 (87.22%) was significantly higher than in ZP 600 (82.78%).

In comparison of values of emergence of adults were established that was not significant differences between variants of treatment of insecticides. Also, the interaction of the hybrid insecticide did not significantly affect emergence of adults (Table 3).

The highest average number of ear had a hybrid ZP 666 in the treatment T3 (treated with a combination of Match and Nurelle) a total of 55 maize ear. The lowest average number of ear had the hybrid ZP 427 in the treatment T4 (treated with Phobos in the second generation of insect), a total of 48 ear. The differences found in the number of ear in hybrids were not statistically significant and no effect was found between hybrids, insecticide treatment or hybrid / insecticide interaction (Table 4).

In ZP 427 hybrid, the highest mass of ear (292.9 g) was on treatment (T4) with applied *Fobos* in the second generation of insect and on treatment (T5) with applicated combination of *Match* and *Nurelle* in the second generation of insect (284.4 g) which was highly significant higher than mass of ear (254.5 g) on the treatment (T2) with application of *Fobos* in the first generation of insect, and significatly higher than mass of ear 261.5 g on the treatment (T3) with application combination of *Match* and *Nurelle* in the first generation of insect and than mass of ear 263.8 g on control variant (T1) (without application of insecticide), Table 5.

Table 4. Average number of ear in maize hybrids

Maize hybrids	Treatments*					
	T1	T2	T3	T4	T5	Average
ZP 427	53.67 ± 1.86	50.33 ± 0.88	51.00 ± 2.52	48.00 ± 1.00	51.00 ± 1.73	50.80
ZP 434	53.00 ± 2.00	53.33 ± 2.33	52.67 ± 1.20	51.67 ± 0.88	52.67 ± 1.76	52.67
ZP 555	51.33 ± 3.76	52.33 ± 1.20	52.33 ± 1.20	49.00 ± 4.51	53.00 ± 2.08	51.60
ZP 600	51.33 ± 2.33	48.67 ± 4.37	51.00 ± 1.73	51.33 ± 1.45	51.00 ± 4.04	50.66
ZP 606	53.33 ± 0.88	53.67 ± 0.33	54.33 ± 0.88	53.67 ± 0.33	53.67 ± 0.88	53.73
ZP 666	53.00 ± 1.00	50.67 ± 1.20	55.00 ± 2.08	54.67 ± 1.67	52.33 ± 0.33	53.11
Average	52.61	51.50	52.72	51.39	52.28	
F-test	F-value			P-value		
F-test for hybrids	1.9701			0.0883		
F-test for insecticides	0.5673			0.7039		
F-test for interaction	0.4493			0.9731		
LSD test	0.05			0.01		
LSD for hybrids	NS			NS		
LSD for insecticides	NS			NS		
LSD for interaction hybrids × insecticides	NS			NS		

*T1 = control variant, T2 = treated with *Fobos* in the first generation of insect, T3 = treated with combination of *Match* and *Nurelle* in the first generation of insect, T4 = treated with *Fobos* in the second generation of insect and T5 = treated with combination of *Match* and *Nurelle* in the second generation of insect. All values are presented as arithmetic mean ± standard error.

ZP 434 hybrids had the highest mass of ear (282.3 g) was on treatment (T5) with application of combination of *Match* and *Nurelle* in the second generation of insect and highly significant higher than mass of ear on all variant of treatment: (T2) with application of *Fobos* in the first generation of insect (236.6 g) , T4 - with *Fobos* in the second generation of insect (238.5 g), T3 - with application of combination of *Match* and *Nurelle* in the first generation of insect (251.5 g) and on control variant (T1) (without application of insecticid- 263.3 g). Also, mass of ear 263.3 g on control variant (T1) was and highly significant higher than mass of ear 236.6 g on the treatment (T2) and significantly higher than mass of ear 238.5 g on the treatment (T4) with application of *Fobos* in the second generation of insect (Table 5).

The mass of ear in ZP 555 was the highest (303.1 g) on treatment T3 - with application combination of *Match* and *Nurelle* in the first generation of insect and highly significant higher than mass of ear 262.6 g on the treatment T4 with *Fobos* in the second generation of insect and mass of ear 258.3 g on the treatment (T2) with *Fobos* in the first generation of insect and significantly higher than mass of ear 279.8 g on control variant (T1) (without application of insecticide). Also, mass of ear 287.1 g on the treatment (T5) with application combination of *Match* and *Nurelle* in the second generation of insect was highly significant higher than mass of ear 258.0 g on the treatment (T2) with application of *Fobos* in the first generation of insect and significantly higher than mass of ear 262.6 g on the tratment (T4) with application of *Fobos* in the second generation of insect. Mass of ear 279.8 g on control variant (T1) (without application of insecticide) was significantly higher than mass of ear than on the tratment (T4) with application of *Fobos* in the second generation of insect. In reamin comparation was not established significant differences between treatment for mass of ear in hybrid ZP 555.

Table 5. Average mass of ear in maize hybrid (g)

Maize hybrids	Treatments*					
	T1	T2	T3	T4	T5	Average
ZP 427	263.8 ± 6.3	254.5 ± 19.8	261.5 ± 32.7	292.9 ± 32.5	284.4 ± 11.4	271.42
ZP 434	263.3 ± 20.2	236.6 ± 13.7	251.5 ± 22.8	238.5 ± 21.9	282.3 ± 10.3	254.44
ZP 555	279.8 ± 13.5	258.0 ± 5.4	303.1 ± 26.4	262.6 ± 3.9	287.1 ± 3.9	278.12
ZP 600	268.6 ± 11.1	228.3 ± 5.0	257.0 ± 25.9	246.1 ± 18.5	288.5 ± 17.4	257.70
ZP 606	311.6 ± 8.9	259.3 ± 2.8	281.1 ± 15.0	278.1 ± 11.0	289.7 ± 7.4	283.96
ZP 666	288.2 ± 16.8	256.2 ± 10.3	275.0 ± 19.8	295.8 ± 4.4	294.9 ± 4.6	282.02
Average	279.21	248.82	271.53	269.0	287.82	271.28
F-test	F-value			P-value		
F-test for hybrids	2.9474			0.0194		
F-test for insecticides	4.7384			0.0022		
F-test for interaction	0.6349			0.8693		
LSD test	0.05			0.01		
LSD for hybrids	20.7389			27.5932		
LSD for insecticides	18.9320			25.1890		
LSD for interaction hybrids × insecticides	NS			NS		

*T1 = control variant, T2 = treated with *Fobos* in the first generation of insect, T3 = treated with combination of *Match* and *Nurelle* in the first generation of insect, T4 = treated with *Fobos* in the second generation of insect and T5 = treated with combination of *Match* and *Nurelle* in the second generation of insect. All values are presented as arithmetic mean ± standard error.

In ZP 600 hybrids the highest mass of ear (288.5 g) was on the tratment (T5) with application of combination of *Match* and *Nurelle* in the second generation of insect which was highly significant higher than mass of ear on all variant of treatment: T3 (257.0 g) - with application combination of *Match* and *Nurelle* in the first generation of insect, T4 (246.1 g) –

with application of *Fobos* on the second generation of insect, T2 (228.3 g) with application of *Fobos* in the first generation of insect, and significantly higher than on treatment T1 – control (without application of insecticide -268.6 g). The mass of ear 268.6 g on treatment T1 – control (without application of insecticide was the highly significant higher than mass of ear on treatment T'4 with application of *Fobos* in the second generation of insect (246.1 g) and on ttreatment T2- with application of *Fobos* in the first generation of insect (228.3 g), while mass of ear 257.0 g on treatment T3 - with application of combination of *Match* and *Nurelle* in the first generation of insect was significantly higher than on treatment T2- with application of *Fobos* in the first generation of insect (228.3 g), Table 5.

The mass of ear in ZP 606 was the highest (311.6 g) on treatment T1 – control (without application of insecticide which was the highly significant higher than mass of ear on treatment: T3- with combination of *Match* and *Nurelle* in the first generation of insect (281.1 g), T4- with application of *Fobos* in the second generation of insect (278.1 g), T2 – with application of *Fobos* in the first generation of insect (259.3 g) and significantly higher than on treatment T5- with combination of *Match* and *Nurelle* in the second generation of insect (289.7 g). The mass of ear 289.7 g on treatment T5- with application of combination of *Match* and *Nurelle* in the second generation of insect was highly significant higher than mass of ear 259.3 g in treatment T2 – with application of *Fobos* in the first generation of insect, while the mass of ear 281.1 g on treatment T3- with application of combination of *Match* and *Nurelle* in the first generation of insect was significantly higher than on treatment T2 - with combination of *Fobos* in the first generation of insect (259.3 g) The value of mass of ear 278.1 g in treatment T4- with application of *Fobos* in the second generation of insect was significantly higher on the level of highly significant diferences than mass of ear 259.3 g in treatment T2 - with *Fobos* in the first generation of insect.

In ZP 666 hybrids the highest mass of ear (295.8 g) on treatment T4- with application of *Fobos* in the second generation of insect and the lowest 256.2 g on the treatment T2 - with application of *Fobos* in the first generation of insect. The mass of ear 295.8 g on treatment T4- with application of *Fobos* in the second generation of insect and mass of ear 294.9 g on the treatment T5- with application of combination of *Match* and *Nurelle* in the second generation of insect as well mass of ear 288.2 g on treatment T1 control variant without insecticide were the highly significant higher than mass of ear 256.2 g on treatment T2 - with application of *Fobos* in the first generation of insect. Also mass of ear 295.8 g on treatment T4- with application of *Fobos* in the second generation of insect and mass of ear 294.9 g on the treatment T5- with application of combination of *Match* and *Nurelle* in the second generation of insect was highly significant higher than mass of ear 275.3 g on treatment T3- with application of the combination of *Match* and *Nurelle* in the first generation of insect (Table 5).

On control variant the highest mass of ear was found in hybrid ZP 606 (311.6 g) which was highly significant higher than and mass of ear at the hybrid ZP 427 (263.8 g), ZP 434 (263.3 g), ZP 555 (279.8 g), ZP 600 (268.6 g) and significantly higher than mass of ear at the ZP 666 (288.2 g). The mass of ear at the hybrid ZP 666 (288.2 g) was significantly higher than mass of ear at the hybrids ZP 427 (263.8 g), ZP 434 (263.3 g). In reamin comparation was not established significant differences between hybrids for mass of ear on this treatment T1-control without application of insecticide.

On variant (T2) with application of *Fobos* in the first generation of insect, the highest mass of ear was found at the hybrid ZP 606 (259.3 g) which was highly significant higher than and mass of ear at the hybrid ZP 600 (228.3 g) which was the lowest in this treatment. The mass of ear at the hybrid ZP 600 (228.3 g) was significantly lower than mass of ear at the hybrids ZP 427 (254.5 g), ZP 555 (258.0 g), ZP 606 (259.3 g) and ZP 666 (256.2 g). The mass of ear at the hybrid ZP 606 (259.3 g) was significantly higher than mass of ear at the ZP 434, (236.6 g), while in remain comparison of hybrids were not found significant difference for mass of ear.

On variant (T3) with application combination of *Match* and *Nurelle* in the first generation of insect, the highest mass of ear was found at the hybrid ZP 555 (303.1 g) and the lowest mass of ear was at the hybrid ZP 434 (251.5 g). Mass of ear in hybrid ZP 434 (251.5g) was highly significantly lower than at the hybrid ZP 555 (303.1 g) and ZP 606 (281.1 g) as well as significantly different than at the hybrid ZP 666 (275.0 g), while values of mass of cob in remain hybrids of corn were not significantly different.

On variant (T4) with application of *Fobos* in the second generation of insect, the highest mass of ear was found at the hybrid ZP 555 (303.1 g) and the lowest mass of ear was in hybrid ZP 434 (251.5g). Mass of ear at the hybrids ZP 434 (238.5 g) and ZP 600 (246.1 g) was highly significantly lower than at the hybrid ZP 606 (278.1 g), ZP 427 (292.9 g) and ZP 606 (295.8 g), also mass of ear at the hybrids ZP 434 (238.5 g) was significantly lower than in hybrid ZP 555 (262.6 g), while values of mass of ear in remain hybrids of corn were not significantly different.

On variant (T5) with application of combination of *Match* and *Nurelle* in the second generation of insect, the highest mass of ear was found in hybrid ZP 666 (294.9 g) and the lowest mass of ear was in hybrid ZP 434 (282.3 g), which was not significantly different. Also, significant differences were not established in comparison mass of ear among other maize hybrids on this variant.

Highly significant differences were found between maize hybrids based on ear weight values on the same variant, highly significant differences for ear mass between hybrids were found on different variants of insecticide application, while no significant differences were not found for ear mass between hybrid / insecticide interaction (Table 5).

DISCUSSION

In this study we analyzed maize hybrids belong to different group of maturity. The variability of traits: grain mass, ear mass, number of ear, grain moisture content of maize hybrids were established. The estimation of this trait conducted in crop maize which infested with European corn borer after applied two different insecticides in two different term. At the same time we can estimate resistance/susceptibility of maize hybrid on pest infestation, harmfulness effect of *Ostrinia nubilalis* Hbn., on maize hybrids, effect of insecticides in the protection of maize crops of harmful effects of *Ostrinia nubilalis*, in the prevention of the development of adult individuals and the suppression of pest attacks *Ostrinia nubilalis* on maize hybrids.

In this study for average grain yield, grain mass, were identified significant differences among maize hybrids and among the treatment with insecticides. The obtained results provide efficient control of pest i.e., estimation for efficient application of insecticide (dose and time) in suppression of attack of *Ostrinia nubilalis* and efficient protection hybrids from damages.

Protective effect of insecticides vary depends of active ingredients, dose and term of application. For decision of term of application insecticides we need conduct monitoring of plant phenology, estimation of moths density during the daylight hours in weed population within or near field of maize or visual estimation of eggs (WADSWORTH *et al*., 2020). If corn borers are present in a field, however, the critical treatment time is just before the tassels emerge, because in this phase of plant development the larvae are active and more likely to contact insecticide.

In agroecological conditions of Zemun Polje, Serbia - the studied maize hybrids had different intensities of *Ostrinia nubilalis* larvae attack in different treatments. However, the results of the LSD contrast test indicated that the total percentage insect attack would differ only in relation to which treatment the hybrid would be treated, but not in relation to the hybrids themselves.

Observing the F-test between maize hybrids in the total ECB attack on maize (Table 1), we come to the data that there was no significant statistical difference between the examined groups. All hybrids had a similar response to the attack of this pest, the differences that manifested themselves were due to different treatments with insecticides at certain times of application. If we compare the average attack on all treatments together, we come to the data that the hybrid ZP 434 showed the best with a percentage average pest attack of 82.29%, while the worst was the hybrid ZP 555 with 87.71%. Other hybrids had an average percentage attack between 83.99 and 84.97%. Similar results are found in the control variant where ZP 434 with 88.76% of attacks had the best results, while the hybrid ZP 606 with an attack of 93.90% had the highest attack.

Similar results in previous investigation, during vegetation season 2018 year, were established in treatment with *Fobos* in the first generation of insect, 81.62% which was the lowest value of attack of European corn borer and the highest 91.72% in control variant without application of insecticide (GOŠIĆ DONDO *et al*., 2020). In another investigation in Romania during season 2016 year were found that attack of European corn borer varied in range from 67.50% to 97.50% while during the season 2017 year attack of European corn borer varied in range from 67.50% to 86.25% (GEORGESCU *et al*., 2019). Similar results were obtained by the same authors in the view set a few years earlier (GEORGESCU *et al*., 2015).

In this study we found that application of insecticide *Fobos* (bifentrin) in the first generation of insect in average had the most efficient in protection to emergence of adults (86.85%) and suppression of attack *Ostrinia nubilalis* (81.56%). The most efficient prevention effect showed treatment T2-with application insecticide *Fobos* in the first generation of insect in maize hybrid ZP 434 in which whole intensity attack of European corn borer was the lowest (77.12%). Also, in this treatment T2, the lowest attack intesity identified in hybrids ZP 555 (83.00%) and in ZP 606 (81.87%) in comparison to intensity of ECB attack on the remain three treatments.

Also high efficient protection from ECB was on T3 - with applied combination of *Match* and *Nurelle* in the first generation of insect identified at the ZP 600 (81.89%), on T4 with application of *Fobos* in the second generation of insect found at the ZP 666 (80.38%), and on T5 – with application of combination of *Match* and *Nurelle* in the second generation of insect, the ZP 427 (80.20%) and at the ZP 600 (80.87%) was identified the smallest attack intensity of European corn borer.

The smallest efficiency of protection from European corn borer attack was found in treatment T5 - with combination of *Match* and *Nurelle* in the second generation of insect at the maize hybrid ZP 555 (92.02%), while in average among all the four treatments with insecticides, the smallest efficiency of protection was found on T3 (83.74%) in average for all six analyzed hybrids. The value of attack on T3 was higher than on remain three treatment T2, T4 and T5, while was high significant lower than on T1-control variant.

On treatment T1- control variant, without application of insecticide the intensity of attack of European corn borer variate from the lowest at the maize hybrid ZP 434 (88.76%), to the highest at the maize hybrid ZP 666 (94.28%), while in average emergency of adult and intensity of attack of ECB were significantly higher than on variant treated with insecticides (T2, T3, T4 and T5). Generaly, high values of infestation of hybrids on control variant associated with low values of mass of grain, mass of ear in those hybrids and in average at the all maize hybrids.

The differences between T1- control variant (without insecticide protection) and other four variant T2, T3, T4 and T5 with application of different insecticides at different term were significant.

The obtained results can use to improving approach in protection of maize hybrids against *Ostrinia nubilalis* Hbn., because we have already identified hybrids with better value of ear trait, resistance to attack under certain application of insecticides. The contribution of these results can be in selection hybrid for crop production in certain environment and known treatment with insecticides (MITCHELL *et al*., 2016).

CONCLUSIONS

On the base of results, the differences among maize hybrids for analzed traits of ear were established. Also, differences among maize hybrids according to intensity of attack of European corn borer (*Ostrinia nubilalis* Hbn.) depending on treatment with insecticides. All hybrids had a similar response to the attack of this pest, the differences that manifested themselves were due to different treatments with insecticides at certain times of application. The established differences between maize hybrids was not significant.

The hybrids ZP 434 expressed the highest resistance to pest which had the lowest attack intensity of European corn borer per plant was (82.29%) in average for all treatments the, while the highest attack intensity was in hybrid ZP 555 (87.71%) in average for all treatments

In average for all analyzed hybrids the lowest attack intensity of European corn borer established in treatment T2 with application insecticide *Fobos* in the first generation of insect (81.54%) which is highly significant lower than in average value for hybrids in control variant T1 tretmant without insecticide (91.75%). Also, attack intensity of European corn borer in treatment T2 (81.54%) was lower than in remain variant of application insecticides T3 (83.74%), T4 (82.54%) and (83.55%) in average for all analyzed hybrids.

The most efficient prevention effect showed treatment T2-with application insecticide *Fobos* in the first generation of insect in maize hybrid ZP 434 in which whole intensity attack of European corn borer was the lowest (77.12%). Also, in this treatment T2, the lowest attack intensity identified in hybrids ZP 555 (83.00%) and in ZP 606 (81.87%) in comparison to intensity of ECB attack on the remain three treatments.

In treatment T3, T4 and T5 with applied insecticides, the attack intensity of European corn borer (83.54%, 82.54% and 83.55%) in average for all hybrids was highly significant lower than attack intensity on control variant T1 (91.75%).

The highest efficient of protection from European corn borer attack was found in treatment T2 with application insecticide *Fobos* in the first generation of insect at the hybrid ZP 434 (77.12%), ZP 555 (83.02%) and at the ZP 606 (81.87%). Furthermore, it was found on T3 - with applied combination of *Match* and *Nurelle* in the first generation of insect identified at the ZP 600 (81.89%), on T4 with application of *Fobos* in the second generation of insect found at the ZP 666 (80.38%), and on T5 – with application of combination of *Match* and *Nurelle* in the second generation of insect, the ZP 427 (80.20%) and at the ZP 600 (80.87%) was identified the smallest attack intesity of European corn borer.

ACKNOWLEDGEMENTS

The research was funded by the Ministry of Education, Science and Technological Development of Republic of Serbia (TR 31092).

Received, September 13th, 2021

Accepted February18th, 2022

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UTICAJ HIBRIDA KUKURUZA I PRIMENJENIH INSEKTICIDA NA NAPAD *Ostrinia nubilalis* HBN.

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Izvod

Ostrinia nubilalis Hbn. je štetočina kukuruza koja u pojedinim godišnjim dobima može naneti veliku štetu biljkama. Cilj ovog rada je proučavanje otpornosti odnosno podložnosti hibrida napadu kukuruznog plamenca i efekata različitih doza insekticida i vremena primene u zaštiti od ove štetočine na biljkama kukuruza, ali prvenstveno uticaj hibrida na intenzitet napada. Šest hibrida kukuruza različitih grupa zrenja (ZP 427, ZP 434, ZP 555, ZP 600, ZP 606 i ZP 666) korišćeno je za proučavanje dejstva napada *Ostrinia nubilalis* Hbn., na kontrolnu varijantu T1 bez primene insekticida i na varijantu tretiranu sa dva insekticida Fobos EC (bifentrin - 200 ml ha-1) i kombinacijom Match 050 EC i Nurelle D (lufenuron 50 g l-1 i hlorpirifos 500 g l-1 + cipermetrin 50 g l-1), 0.75 l ha-1) u dva termina (u prvoj generaciji za vreme leta insekata T2 i T3 i u drugoj generaciji za vreme leta insekata T4 i T5) u tri ponavljanja. Rezultati su pokazali najveći intenzitet *Ostrinia nubilalis* Hbn. napad i stepen oštećenja na kontrolnoj varijanti i značajne razlike između tretmana za ispitivane parametre. Posmatrajući sve hibride i tretmane, nije utvrđena statistička značajnost između šest ispitivanih hibrida kukuruza različitih grupa zrelosti. U kontrolnoj varijanti najveći napad (oštećenje) je bio na biljkama kod hibrida ZP 666 (94,28%) i ZP 606 (93,90%), a među varijantama primenjenih insekticida najveća šteta je konstatovana u tretmanu T5 sa primenjena kombinacija Match + Nurelle u hibridu ZP 555 i iznosila je 92,02%. Na tretmanu T1-kontrolna varijanta bez insekticida, najmanji napad sa *Ostrinia nubilalis* Hbn. je konstatovan kod hibrida ZP 434 (od 88,76%), a među varijantama primenjenih insekticida najmanji napad je konstatovan kod varijante T2 sa primenjenim Fobos kod prve generacije insekata u hibridu ZP 434 i iznosio je 77,12%. Napad *Ostrinia nubilalis* Hbn. i varijacija prosečne mase klipa kukuruza varirala je u zavisnosti od hibrida kukuruza i vremena primene insekticida.

Primljeno 13.IX.2021.
Odobreno 18. II. 2022.