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Original scientific article

VARIABILITY OF MAIZE GENOTYPES IN THE EXPRESSION OF TOLERANCE TO EUROPEAN CORN BORER (*Ostrinia nubilalis* Hbn.)

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The backbone of modern technologies is the creation of tolerant genotypes at the ECB with special emphasis on the interaction between the degree of plant damage and metabolic processes as potential responses to stress. During the vegetation period of 2016 and 2018, the variability and response of four maize genotypes to the effectiveness of insecticides and bioinsecticides and the interdependence with the dynamics of the ECB population were examined. Out of a total of 11,023 attacked plants in both years of the survey, in 2016 the largest number of plants (4,841) with a broken stalk above the ear and at the height of the ear and belonged to categories C_3 to C_8. In 2018, there was no damage to the tassel and ear, while 3,672 plants were dominated by leaf damage and perforation in the H_2 type. In addition to the fact that more infested plants were observed in the genotypes, ZP 434 and ZP 666 the categories of damage type C_5, C_6 and C_7 were more pronounced. The foliar treatment of plants with chlorantraniliprole in two-year research

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proved to be the most effective with the least number of attacked plants with a high degree of damage. In contrast, bioinsecticide treatment of plants, in addition to a large number of infested plants, was dominated by high categories of damage that deviated from all other treatments as well as from control. Within the definition of the degree of tolerance of maize genotypes, the influence of treatment on changes in secondary metabolites (phytins) in seeds was observed. It was noticed that there is a trend of positive correlation between the amount of phytin in the seed (mg g^{-1}) with the attack of moths of the first generation and the number of dissected larvae, as well as a trend of negative correlation with the percentage of attacks of the second generation. Correlation coefficients are expressed: in the genotype ZP-600, while in the genotype ZP-666 correlation is the lowest, ie. irrelevant. The obtained results may be of great importance in future work aimed at the selection of maize genotypes tolerant and resistant to corn borer attack, connected to the role of phytin, as an antioxidant and phosphorus deposited in corn grain.

Keywords: maize genotypes, tolerance, *Ostrinia nubilalis*

INTRODUCTION

Maize (*Zea mays* L) is one of the most common crops with a constant tendency to adapt to different growing conditions. Due to its high genetic potential, maize production globally is 9,607,000,000 t on approximately harvested an area of 177 million hectares (HEGDE *et al*., 2017). With an area of 1,002,319 ha, which is 7.89% of the total production in Europe, Serbia ranks 12th on the list of the largest producers of maize (STATISTICAL OFFICE OF THE REPUBLIC OF SERBIA (2018); THE DAILY RECORDS, 2019). It is grown either as monoculture or in rotation with other crops and the crop protection practised is mainly pesticide-based with different levels of (IPM) adoption (VASILEIADIS *et a*l., 2011). Large areas and numerous possibilities for its exploitation have made maize one of the most strategically important crops.

Among the 925,000 described and identified insect species, less than 100 are economically significant maize pests. The order Lepidoptera, which ranks second globally with 180,000 species (WORLDATLAS.COM), includes European corn borer (ECB), (*Ostrinia nubilalis* Hbn.), a family *Crambidae*, which dominates the world due to its destructiveness and polyphagousness, as one of the most important pests of corn. On the territory of Serbia, it is represented by two, rarely three generations per year, and in favourable agroecological conditions, it can be significantly distinguished by the high number of moths, the percentage of attacked plants and the degree of damage. At the heart of the nutritional capacity of ECB and corn plants are food needs and caterpillars, whose way of life is mostly related to the interior of the stalk. The larvae damage all aboveground parts of the plant with their diet, which disrupts the transport of nutrients and water, the content of primary and secondary metabolites and can significantly reduce the yield and quality of corn grains (BOURGET *et al*., 2000; STAMPS *et al*., 2007).

By increasing the area under corn with all the agrotechnical measures that are being implemented, the total losses from ECB can reach a high threshold of harmfulness in certain years. According to the sensitivity of genotypes, the damage may vary from only a few per cent in tolerant genotypes, to 30-40% in moderately intolerant genotypes. Yield is affected by *O.*

nubilalis damage to the ear and larvae tunnelling in the stalk resulting in breakage (BUTRON *et al*., 2009). The presence of only one larva can reduce cob yield from 2 to 6% (LISOWICZ and TEKIELA, 2004).

In order to prevent a high population level of this pest, a complex approach based on combining agrotechnical, chemical and biological aspects of maize protection is necessary. These studies aimed to evaluate the variability and bioresponsiveness of different maize genotypes to applied insecticides and bioinsecticides and the inter-dependence ECB control measures based on the occurrence of forecasts of and size of the height of the population on the light trap. Also, to observe variations in the degree of damage to plants after the diet of ECB caterpillars, to determine the quantitative impact of some of the secondary metabolites on the degree of damage, i.e. tolerance to the corn borer, as well as to examine the effectiveness of several insecticides and bioinsecticides, which would realize adequate protection of genotypes different in vegetation length.

MATERIALS AND METHODS

Design of experiments in field conditions

The reaction of four maize genotypes (1-ZP 427, 2-ZP 434, 3- ZP 600 and 4-ZP 666) on the effectiveness of insecticides and bioinsecticides and interdependence with the dynamics of the ECB population was investigated in the experimental field of the Maize Institute Zemun Polje, Serbia (44º 86' 85.10'' N, 20º 33' 68.07'' E). Within the definition of the degree of tolerance of maize genotypes, the influence of treatment on changes in secondary metabolites in seeds was observed.

The experiment was set up with a randomized complete block system (RCB) design, split-plot experimental design in three replications. The first factor of the experiment is the time of plant treatments: Time 1 (V1) - seed treatment immediately before sowing, time 2 (V2), 15 days after the maximum flight of the first generation, June 16 (2016) and June 4 (2018) respectively, time 3 (V3) 15 days after the maximum flight of the second generation, August 10 (2016) and July 18 (2018). The subfactors are insecticides for seed treatment and three different foliar insecticides as well as one registered bioinsecticide. Immediately before sowing, the seeds were treated with concentrated seed treatment suspensions (FS): TS-1 Sonido (thiacloprid, Bayer) in the amount of 62.5 ml per sowing unit (25,000 seeds) and TS-2 Semaphore (bifenthrin, FMC) in the amount of 300 ml per 100 kg of seeds. Foliar insecticides were applied with a motor atomizer in the prescribed concentrations, in the following order:

T-1 Chlorantraniliprole (Coragen, Du Pont, concentrated suspension (SC), 100 ml ha^{-1}, T-2- Indoxacarb (Avaunt, Du Pont,) concentrated emulsion (EC) in a concentration of 250 ml $ha^{-1,}$ T-3 - Deltamethrin (Decis 2.5 EC, Bayer, concentrated emulsion (EC) in a quantity of 400 ml ha^{-1} and bioinsecticide T4- *Bacillus thuringiensis ssp. kurstaki* (Lepinox Plus, 32000 IUTni / mg, CBC, wettable powder formulation, concentration 750 ml ha^{-1}. All treatments were compared with the untreated control (C).

The sowing of maize genotypes was performed by machines on the 22nd April, 2016 and 28th April, 2018, in 3 rows of 5 m length with a distance between rows of 0.7 m and compliant with European and Mediterranean Plant Protection Organization (EPPO) standards (pp 1/13 (3)). The size of the elementary plot was 10.5 m^2, the distance between the plants in a row was 25cm, which makes a set of 57,143 plants per ha.

In assessing pest tolerance, in addition to visual assessment, attention is given to the achieved set of plants, the percentage and the assessment of corn borer attacks based on the total damage to plants on a scale of 1-10 (Fig. 1). In July and September, the intensity of corn borer attacks was assessed, taking into account the damage to all above-ground parts: leaves, tassel, stem and corn cobs. In addition to the above parameters, dissection of all plants by genotypes and treatments, after harvest or during winter diapause, determined the number of openings and channels in the stem, channel length, number of living and dead caterpillars. Harvesting was done by hand, after which all plants were adequately marked and prepared for further laboratory analysis.

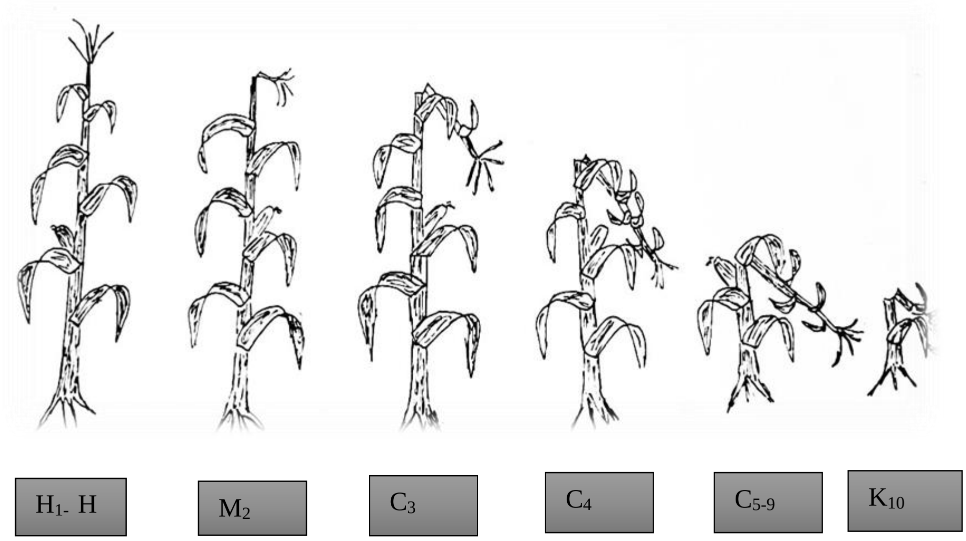

Fig .1. Scale of plant damage: (HADŽISTEVIĆ, 1969), H_{1-2} damage to corn leaves and perforation in the stem C_{3-4} Broken stem on the first or second internode under the tassel C_5 plants broken at ear height C_{6-9} plants broken under the cob and the cob is badly damaged M_2 with heavily infested leaves and a broken tassel K_{10} plants with fallen cobs

Corn borer population

The dynamics of the corn borer population is determined on the basis of the population size and the degree of plant damage. The flight of the moths was monitored on a light trap of the PZB-50 Agrobečej type during the vegetation period from May to September. The number of registered males and females was determined daily. To create a curve of average flight dynamics, the share of each specimen was calculated on an annual basis.

Chemical analysis

Chemical analyses included the determination of concentrations of secondary metabolites –phytin in maize seeds of different genotypes and treatments from the 2018 experiment. The seeds were ground and the phytin content was determined according to the method of DRAGIĆEVIĆ *et al*. (2011).

Statistical analyzes

The obtained data were used for a three-way analysis of variance (ANOVA - F test) using M-STAT-C software (Michigan State University, 1989). Differences between treatments were tested by the least significant difference test (LSD 0.05).

RESULTS AND DISCUSSION

The development of the maize plant during the entire vegetation is significantly related to the life cycle of the European Corn Borer. In May, when maize is usually in the four-leaf stage, first-generation moths appear and females lay eggs. It is generally known that females choose plants for laying eggs according to their height and vegetative phase of development. Tall plants are more attractive for laying females of the first generation (WRIGHT, 2013). The maximum of summer and numerical gender equality was in the third decade of May 2018 and the first decade of June 2016. Intensive flight of moths of the first generation of ECB in Zemun Polje and exposure of maize plants to mass laying of egg litters takes place from May 21 to July 3, depending on the year (Fig. 2). CIZEJ *et al*. (2017) in the eighteen-year monitoring (1999-2016) of the ECB flight recorded a significant increase in the number of first-generation moths in the third decade of May with a peak in flight on 10 June. The flight of the first generation in 2016 which lasted 47 days, had 2 peaks in flight and 910 moths, which makes up 9.5% of the total population. The share of the first generation in the total number of moths in 2018 was 17.2% and lasted for 43 days.

An extremely high percentage of second-generation moths was recorded in both years (82.8 and 90.6%). The specificity of 2016 was reflected in the extremely high number of moths (9,631), of which 8,721 belonged to the second generation, which began its flight on July 11 and lasted until September 16. In the territory of Hungary, based on the moth's flight curve diagram, during three years of research, KESZTHELYI (2004) also noticed that the flight of the second far exceeds the flight of the first generation. An extremely high number of second- generation moths can be explained by optimal conditions for moths development, which is especially indicated by average monthly temperatures for the growing season of 20.3 °C, which is optimal for oviposition and development of larvae and pupae. The population peak of the second generation was on July 25, 2016, with 655 moths per night, and on July 3, 2018, with 180 moths per night when the average daily temperature of 27.9°C was registered, which is optimal for this thermophilic-hygrophilous species optimal factor for mass reproduction (RHMZ of Serbia).

By analyzing the total number of plants (13,074) by categories of damage in both years of research, 11,023 had symptoms of ECB attacks (84.3%). For a more detailed insight into the structure of damage, the scale covered the range from H_2 to K_{10}. Following the degree of damage to the aboveground parts of the plant in full maturity, it was noticed that in 2016 the largest number of plants (4,841) were with a broken stalk above the ear and at the height of the ear and belonged to categories C_3 – C_8, most often caused by transverse burrows of second-generation larvae (Fig. 3). Higher categories of damage can be related to the high level of the second generation moths population. STAMPS *et al*. (2007) confirmed that the high level of population and the damage that larvas cause with their diet have a destructive effect on all aboveground parts of the maize plant. In the research of GOŠIĆ-DONDO *et al*. (2015); it was reported that the degree of damage increases with the participation of the second generation in the overall attack. In 2018, there was no damage to the tassels and ears, while damage to leaves and perforation in the H_2 type stalk was the most common with 3,672 attacked plants, which is (66.6%) of the total attack that year (Fig.4).

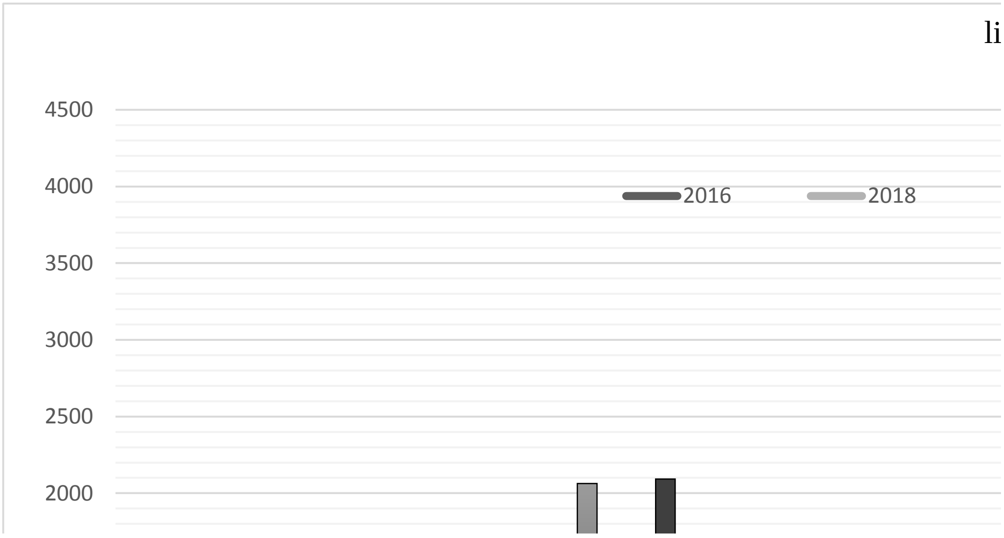

Fig .2. Flight of ECB during the 2016 and 2018 corn-growing season

In the next phase of the research, the differences in the intensity of the first and second generation ECB attacks on 4 ZP genotypes belonging to FAO groups 400 and 600 were assessed. Analyzing the degree of damage to plants caused by the nutrition of the first generation of larvas was dominated by leaf damage mass of type H_1, while the degree of damage from the second generation was significantly higher. By comparing the results on the number of infested plants and the degree of damage by FAO maturity groups and years of testing, and taking into account the heterogeneity of genotypes and their attractiveness for oviposition, it was found that the total number of infested plants did not increase dramatically with the length of maize genotype vegetation. Based on the results shown in Figure 3, it follows that in the conditions of natural attack of corn borer in 2016, the largest number of infested plants was recorded in the genotype ZP 427 (1,431), while in other genotypes that number was fairly uniform. The situation in 2018 was somewhat different, the number varied in the range from 1,294 in the genotype ZP 600 to 1,471 in the genotype ZP 434. Following the categories of damage by genotypes, in addition to the fact that genotypes ZP 434 and ZP 666 observed a higher number of attacked plants, were more pronounced and damage categories of type C_6 and C_7. The reason for this can be found in the fact that these two genotypes share a common parent component that probably influenced and caused a similar attack by the ECB. In both years, it was observed that the genotype ZP 600 had the lowest number of plants with the stated categories of damage (37 and 13). This can be explained by the fact that the parent components that participate in its creation have longer vegetation than the genotypes ZP 434 and ZP 666. The mother of the genotype ZP 600 is susceptible to *O. nubilalis*, so the father is responsible for the resistance of this genotype. In addition, the strong robust stem of this genotype can significantly affect the reduced degree of damage from ECB larvae. It was stated in RASPUDIĆ *et al.* (1999) that the potential reason for the tolerance of genotypes to damage by the ECB should be sought in a strong and robust plant stem. The genotype ZP 427 is three-line, the mother is created from the father lines of the genotypes ZP 434 and 666 and the father of the genotype ZP 600, while the final father of this genotype is the earlier line moderately sensitive to ECB attack (Fig. 3 and 4). Therefore, it is understandable that according to the intensity of ECB attacks, this genotype is between the other two mentioned above. The results of research conducted in Croatia, related to differences in FAO maturation groups in the intensity of ECB attacks, contradict each other and show neither the importance of genotypes nor tolerance towards the ECB. IVEZIĆ *et a*l. (1997) recorded ECB attack rates against FAO maturation groups: 66.01% in FAO 400; 65.14% at FAO 500; 71.76% for FAO 600 and 55.57% for FAO 700. RASPUDIĆ *et a*l. (2010) studied differences in the damage caused by the ECB to genotypes from FAO 400 to FAO 600. This study did not show statistically relevant differences. Based on the analysis of grouped results, the total number of attacked plants depended on the participation of moths in the attack, year and sowing time, while the damage categories depended on the morphophysiological condition of the plant and the increased number of larvae in the stalk below the cob.

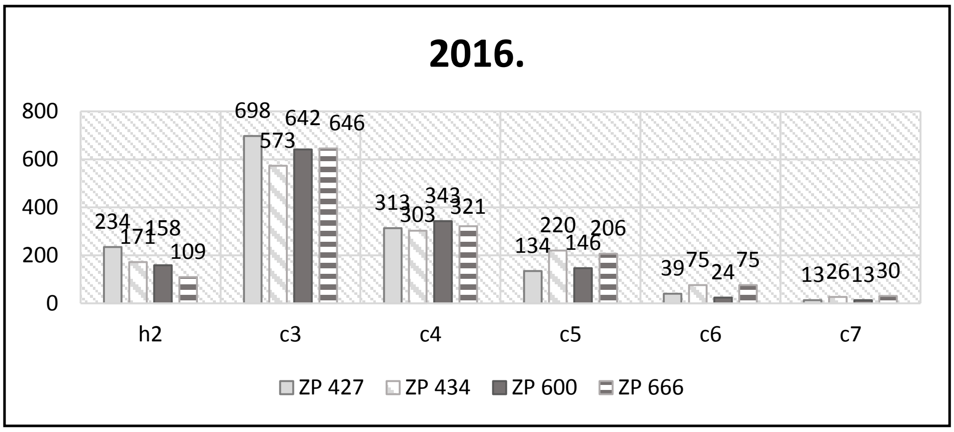

Fig.3. The number of infested plants by European corn borer by a degree of damage and different maize genotypes in 2016

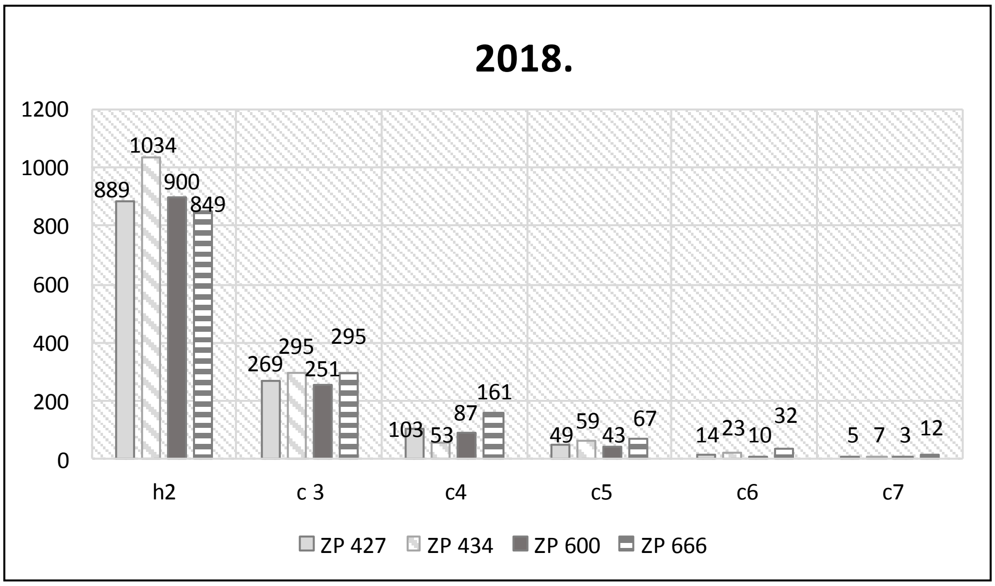

Fig 4. The number of infested plants by European corn borer by a degree of damage and different maize genotypes in 2018

In addition to the dynamics of moths flight and the vegetative period of plant development according to FAO maturation groups, the influence of insecticides on the intensity of plant damage from sprouting to tasselling and silking was monitored. The impact of insecticides and biopesticides on the total number of infested plants by damage categories and times of their application is presented in Figures 5 and 6. The results showed that there are significant differences between damage categories of treated plants and control in all three application times. The results obtained are in agreement with many researchers (BHAT and BABA, 2007; BERES, 2010; HEGDE *et al.*, 2017, VASILEIDAIS *et al*., 2017, GRČAK *et al*., 2022), who also found differences in the effectiveness of insecticides to control corn borer. Analyzing the efficiency of the examined treatments according to the times of application, uniformity in the number of plants with recorded symptoms of damage was observed. That uniformity was present at all times in 2016 and the second time in the 2018 application, but the representation of attacked plants by damage categories was uneven. Thus, foliar treatment of plants with chlorantraniliprole (T1) in two-year research proved to be the most effective with the lowest number of attacked plants by damage categories (Fig. 6). In Northern Italy, Bologna, during 2017-2018, MAGAGNOLI *et al*. (2021), they also found that the conventional chemical strategy (chlorantraniliprole) showed the best control of ECB infestation, followed by a biological control strategy (*Trichogramma brassicae* Bezdenko and *Bacillus thuringiensis* Berliner) and untreated control. In the third time of the 2018 application, certain deviations were observed, which were reflected in a slightly higher number of attacked plants in treatments 2 and 3 (519 and 513). The results that indicate the effectiveness of these treatments are consistent with the results of

FRANETA *et al*. (2018) and GOŠIĆ-DONDO *et al*. (2020) who determined their lethal effect on ECB larvae. They also found that the effectiveness of insecticides has been linked to changes in larval development and a reduction in the reproductive potential and lifespan of insects. The efficiency of indoxacarb in reducing the number of infested plants was also noticed by REINHARD *et al.* (2008). Accompanying the impact of bioinsecticides in 2016 not only a higher number of attacked plants was observed (547 and 499), but also a stronger degree of damage. A stronger degree was recorded in the third period of 2018 with 216 plants from category C_3, 128 from category C_4 and 150 from category C_{5-8}. Comparing the data obtained in two-year research with identical seed treatments, in the conditions of natural attack, the highest prevalence of plants with C_3 damage was recorded in all tested treatments, which indicates the period of activity of the insecticide active substance and the vegetative phase in which plants are sensitive. Also, based on the number of plants by damage categories, genotypes, treatments and application times, these categories were the most common.

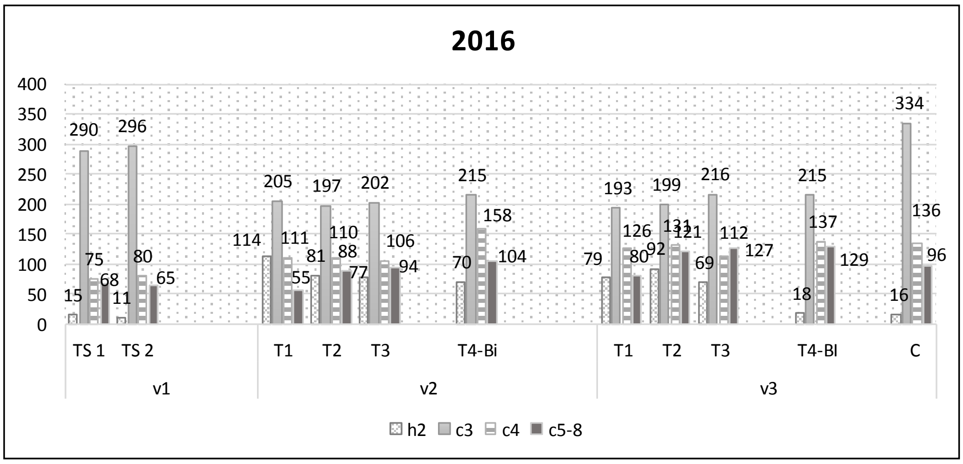

Fig.5. The number of plants by damage categories, genotypes, treatments and application times in 2016.

The analysis of the efficiency of the examined treatments on the degree of damage to plants of different genotypes shows a significant statistical difference between treatments and genotypes. The age and treatment had a significant impact on all examined parameters. Statistical analyzes of the data recorded at each stage showed that insecticides have a significant effect on the intensity of maize tree attacks recorded at different time intervals (Table 1).

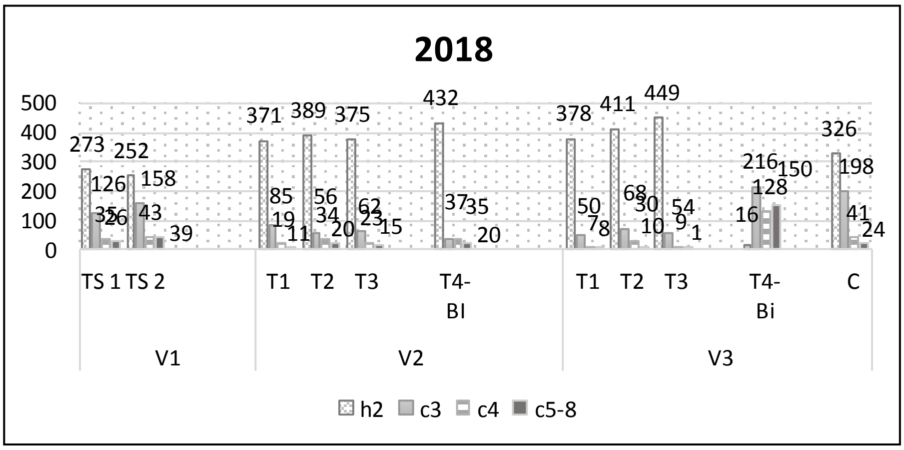

Fig.6. The number of plants by damage categories, genotypes, treatments and application times in 2018.

Table 1. Mean squares from the analysis of variance for the European corn borer damage

Source of variation	MEAN SQUARE (MS) Total ECB damages for scale 1-10					
	H_2	C_3	C_4	C_5	C_6	C_7
Replication (R)	30.015 *	56.182 **	13.754	4.648	4.682*	0.239 **
Year (Y)	35052.136**	7552.061**	3020.40**	992.970**	93.367**	19.636**
Genotype (G)	172.429 **	33.096 *	51.539 **	49.545**	22.135 **	3.985 **
G X Y	127.015 **	74.576 **	21.984 *	22.818 **	6.580 **	1.263
Treatment (T)	945.969 **	464.850 **	86.244 **	35.190**	19.977 **	3.711**
T X Y	424.528 **	110.027 **	60.032 **	26.045**	12.159 **	1.345*
T X G	24.304 **	27.035 **	7.175	5.643*	2.282*	1.460 **
T X G X Y	23.118 **	22.554 **	7.286	5.760*	2.705 **	0.938

*,** probability level of 0,05 and 0,01, respectively

In order to determine the connection of some of the secondary metabolites to the degree of resistance of maize to ECB, regression and correlation analysis determined the interdependence between the percentage of attacks of I and II generation of corn borer, the number of dissected larvae by treatments and genotypes and the amount of phytin in seeds. Regression analysis shows that there is a linear decrease in the percentage of plants infected with second generation ECB larvae with increasing phytin content in the seed, as well as a linear increase in the number of larvae and % of first generation attacks in all 4 examined genotypes. Based on the correlation analysis, it can be seen that there is a trend of positive correlation of the amount of phytin in the seed (mg g^{-1}) with the attack of first generation moths and the number of dissected larvae. Also it is observed a trend of negative correlation with the percentage of second generation moths attacks and significant damage resulting in lower yields (i.e. weaker seed filling). Oposite, a positive correlation between first generation attacks and phytin content could indicate activation of anti-stress mechanisms that further positively affect grain filling and yield. Correlation indices have expressed positive and negative values: in the genotype ZP-600 (Fig. 9), while in the genotype ZP-666, (Fig.10) the correlation is the lowest, ie. irrelevant. These results indicate that the treatments performed in the experiment lead to the most significant change in phytin content in ZP 600, which could be associated with greater tolerance to corn borer attack.

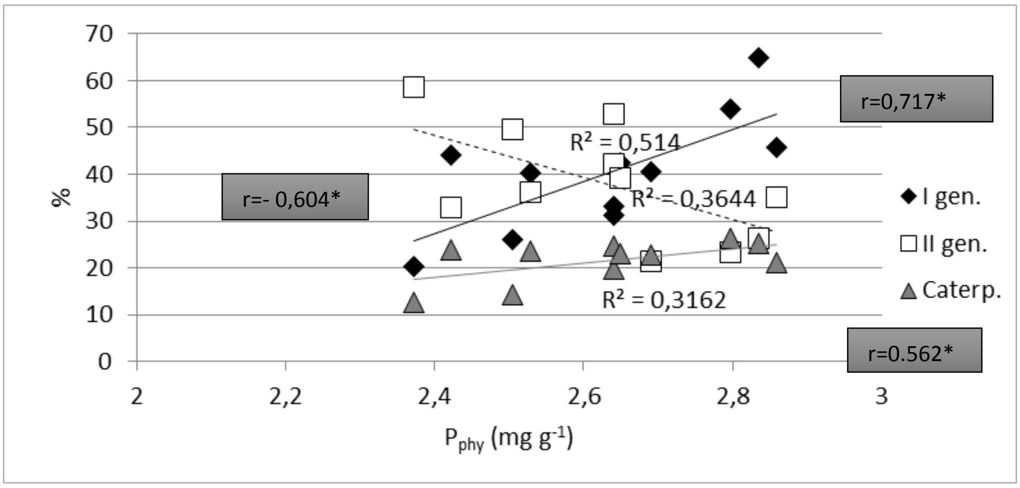

Fig. 7. Regression analysis and the correlation coefficients of phytin content in seeds of genotype ZP 427 and attacks of I and II generation of European corn borer and average number of larvae

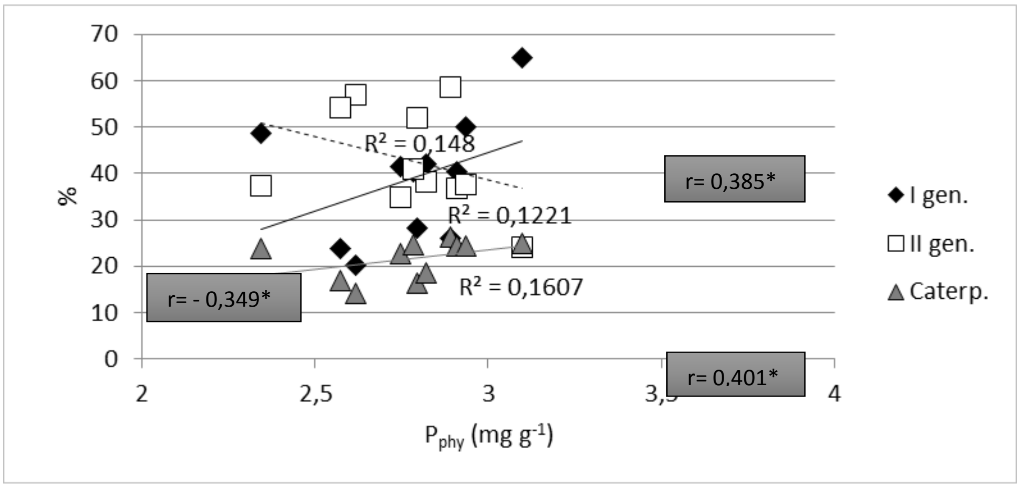

Fig. 8. Regression analysis and the correlation coefficients of phytin content in seeds of genotype ZP 434 and attacks of I and II generation of corn borer and average number of larvae

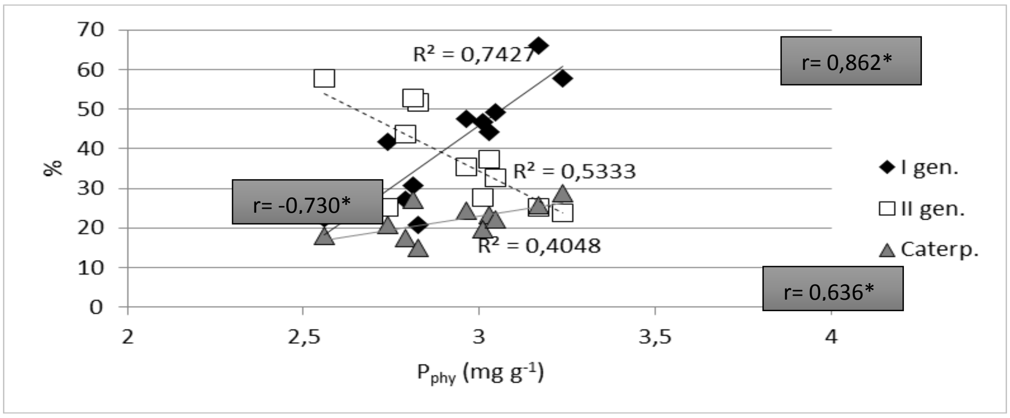

Fig.9. Regression analysis and the correlation coefficients on phytin content in seeds of genotype ZP 600 and attacks of I and II generation of corn borer and average number of larvae

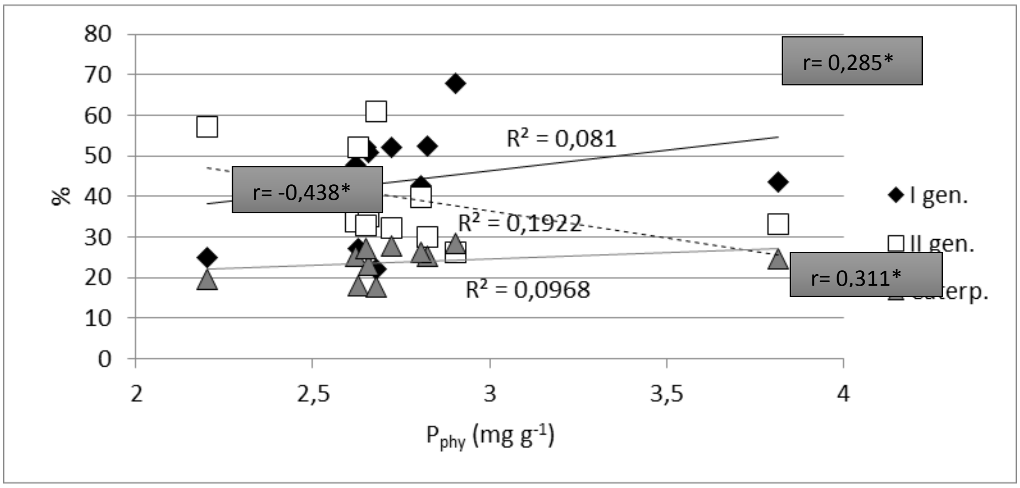

Fig.10. Regression analysis and the correlation coefficients on phytin content in seeds of genotype ZP 666 and attacks of I and II generation of corn borer and average number of larvae

CONCLUSION

The difference in ECB population size between the two years of research was approximately in ration 1:2, which was reflected in oscillations in the degree of attack, both in terms of the percentage of attacked plants and in terms of the degree of damage. Accordingly, in 2016 the largest number of plants was with a broken tree above the piston and at the height of the piston and belonged to categories C_3, C_4 and C_5, and in 2018 dominated by leaf damage and perforation in the tree type H_2. Following the damage categories by genotypes, in addition to genotypes ZP 434 and ZP 666, a higher number of infested plants was observed, and the categories of damage type C_5, C_6 and C_7 were more pronounced. Analyzing the efficiency of the respondent's treatment by application times, uniformity in the number of plants with the recorded symptoms of damage was observed, but the presence of infested plants by categories of damage was uneven. Following the average values of infested plants expressed in percentages, the number of dissected live larvae during 2018 and the content of phytin in the seed, there was a trend of positive correlation of the amount of phytin in the seed (mg g^{-1}) with the attack of moths of the first generation and the number of dissected larvae, as well as a trend of negative correlation with the percentage of attacks of moths of the second generation. Correlation indices are the most pronounced positive values in the ZP-600 genotype, while in the ZP-666 genotype the correlation is the lowest, i.e. without significance. The obtained results may be of great importance in future work aimed at the selection of genotypes tolerant to attack European corn borer, taking into account the role of phytin, as an antioxidant and phosphorus depot in maize grain.

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VARIJABILNOST GENOTIPOVA KUKURUZA U ISPOLJAVANJU TOLERANTNOSTI PREMA KUKURUZNOM PLAMENCU (*Ostrinia nubilalis* Hbn.)

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Izvod

Okosnica modernih tehnologija je stvaranje tolerantnih genotipova na ECB sa posebnim osvrtom na interakcijske odnose između stepena oštećenja biljka i metaboličkih procesa kao potencijalnih odgovora na stres.Tokom vegetacionog perioda 2016. i 2018. godine, ispitivana je varijabilnost i reakcija 4 genotipa kukuruza na efikasnost insekticida i bioinsekticida i međuzavisnost sa dinamikom populacije kukuruznog plamenca. Od ukupno napadnutih 11.023 u obe godine ispitivanja, u 2016. god. najveći broj biljaka (4.841) bio sa prelomljenim stablom iznad klipa i u visini klipa i pripadao kategorijama C_3 do C_8. U 2018. godini, izostala su oštećenja metlice i klipa, dok su kod 3.672 biljke dominirala oštećenja lišća i ubušenja u stablo tipa H_2. Prateći kategorije oštećenja po genotipovima, pored toga što je kod genotipova ZP 434 i ZP 666 uočen veći broj napadnutih biljaka, bile su izraženije i kategorije oštećenja tipa C_5, C_6 i C_7. Folijarni tretman biljaka hloraniliprolom u dvogodišnjim istraživanjima pokazao se kao najefikasniji sa najmanjim brojem napadnutih biljaka visokog stepena oštećenja. Nasuprot tome, kod tretmana biljaka bioinsekticidom pored većeg broja napadnutih biljka, dominirale su visoke kategorije oštećenja koje su odstupala od svih drugih tretmana kao i od kontrole. U okviru definisanja stepena tolerantnosti genotipova kukuruza posmatran je uticaj tretmana na promene sekundarnih metabolita (fitina) u semenu. Uočeno je da postoji trend pozitivne korelacije količine fitina u semenu (mg g^{-1}) sa napadom leptira prve generacije i broja disekovanih larvi, kao i trend negativne korelacije sa procentom napada leptira druge generacije. Korelacioni indeksi su izraženih vrednosti kod dva genotipa - ZP-600 pozitivan indeks, a kod genotipa ZP-666 negativan. Dobijeni rezultati mogu imati veliki značaj u budućem radu usmerenom ka selekciji tolerantnih genotipova na napad kukuruznog plamenca, uzimajući u obzir ulogu fitina, kao antioksidnsa i depoa fosfora u kukuruza.

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