RELATIONSHIP BETWEEN EUROPEAN CORN BORER FEEDING ACTIVITY AND NITROGEN LEAF CONTENT UNDER DIFFERENT AGRICULTURAL PRACTICES

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Relationship between European corn borer feeding activity and nitrogen leaf content under different agricultural practices

Povezanost ishrane kukuruznoga moljca sa sadržajem dušika u listu u sklopu različite poljoprivredne prakse

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SUMMARY

One of the most destructive maize pest in Croatia is European corn borer (Ostrinia nubilalis Hübner) (ECB). The aim of this study was to determine the influence of irrigation, nitrogen fertilization, different maize genotypes and nitrogen leaf content on ECB feeding activity. The experiment was set up in Osijek, Croatia under field conditions during 2012-2013 vegetation season. Experiment treatments were as follows: three irrigation levels (A1 - control, A2 from 60% to 80% field water capacity - FWC and A3 from 80% to100% FWC), three nitrogen fertilizer levels (B1 - 0, B2 - 100 and B3 - 200 kg N/ha) and four different genotypes (C1 - OSSK 596; C2 - OSSK 617; C3 - OSSK 602 and C4 - OSSK 552). Ear weight, number of larvae in stem and shank, tunnel length and nitrogen leaf content were evaluated. Genotype C1 was the most susceptible for following the tested variables of ECB feeding: tunnel length (TL), larvae in stalk (LS) and total number of larvae (TNL) at P<0.05 probability level. By raising the level of irrigation, European corn borer feeding activity was reduced while by raising the level of nitrogen fertilization feeding activity was increased. These results suggest that good production practices can significantly affect the susceptibility of maize to European corn borer.

Key-words: European corn borer, nitrogen fertilization, genotype, irrigation

INTRODUCTION

European corn borer (*Ostrinia nubilalis* Hübner) (ECB) is one of the most destructive maize pest in Croatia whereas maize is the most common grain in this area (Raspudić et al. 2013). In addition to this pest, western corn rootworm (*Diabrotica virgifera virgifera* Le Conte) also occurs every year (Brkić et al., 2012; Ivezić et al., 2009; Ivezić et al., 2011; Šimić et al., 2007). Water and nitrogen fertilizer quantity as well as application period are very important for reducing yield loss by pests. Irrigation and nitrogen fertilization result in higher maize plants. Such plants have higher yield, larger ears, more kernels per ear (Plavšić et al., 2007; Markovic et al., 2011) so they attract corn borer due to providing good food for their larvae (Archer et al., 1987). ECB deposits eggs on the underside of maize leaves. Drought stress may result in a reduction of leaf area up to 33% and plant height to 15% (Traore et al., 2000) .

Addo-Bediako and Thanguane (2012) found that stem borer density was higher in plants from fertilized plots than plants from unfertilized plots. Larvae of European corn borer cause physical damage, disrupt nutrient and water flow in maize stem (Martin et al., 2004).The growth rate of larvae generally increased as plant nitrogen content increased, but varied between different genotypes (Manuwoto and Scriber 2003; Szulc et al., 2008). Greater yield losses are expected with higher ECB infestation levels (Bode et al., 1990).

The aim of this study was to determine the impact of different levels of irrigation, nitrogen rate, maize genotypes and nitrogen leaf content to ECB injury.

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MATERIAL I METHODS

Field experiments with natural population of ECB were conducted in two vegetation seasons (2012-2013) at the Agricultural Institute in Osijek. Maize (*Zea mays* L.) plants were arranged in a randomized block design as split-split plot method within 1 ha field, with three repetitions. Area of basic experimental plots were 14 m^2 (10 m x 2 rows – 0.7 row spacing) (genotype), 56 m^2 (4 genotype x 14 m^2) (N fertilization) and 168 m^2 (4 genotype 56 m^2 x 3 levels of N fertilization) (irrigation). Soil type is specified as eutric cambisol (Soil Survey Division Staff, 1993). This plot is constantly maize – soybean rotation already 15 years. It was a 3 $\times$ 3 $\times$ 4 factorial experiment with three irrigation levels (A1- non-irrigated, A2 - from 60% to 80% field water capacity - FWC and A3 - from 80% to100% FWC), three nitrogen fertilizer levels (B1-0, B2-100 and B3-200 kg N/ha) and four different genotypes (C1 - OSSK 596; C2 - OSSK 617; C3 - OSSK 602 and C4 - OSSK 552). Soil water content has been measured by Watermark soil moisture instrument. 2/3 of N quantities were added in autumn and pre-sowing (urea: 46% N) and the rest by two top-dressings at early growth stages (calcium ammonium nitrate: 27% N). In silking stage (middle of July) ten leaves (below the ear), from 10 maize plants were sampled on each variant. Leaves were cleaned of dust and pollen dried at 70°C for 24 h and crushed. Leaf nitrogen content was determined by the Kjeldahl method. At the end of the growing season, ten maize plants from each variant were cut. Parameters related to ECB feeding activity and maize tolerance, as well as nitrogen leaf content were measured. Tested variable were EW - ear weight (g), TL – tunnel length (cm), LS – number of larvae in stalk, LES – number of larvae in ear shank, ESD – ear shank damage (cm) and nitrogen leaf content (N leaf) (%). Source of the weather data was the State Hydro meteorological Institute in Zagreb. The effect of irrigation, nitrogen fertilization, genotype and ECB injury was evaluated by analysis of variance using the SAS software (SAS Institute Inc., 2009) after normality data test. Log transformation was used to normalize the data. Least square means with the Tukey adjustment for multiple comparisons were then calculated and reported for significance at the 95% confidence level.

RESULTS AND DISCUSSION

Weather conditions were quite different in the tested years (2012-2013). During the vegetation season (April-September) air temperatures were similar in both tested years but higher compared to the 30-year mean (1961-1990). This could be the cause of almost 100% of ECB infestation in field conditions (Raspudić et al., 2013), compared with earlier years when average of natural infestation was 50% (Ivezić and Raspudić, 2001). European corn borer suppression becomes very important agricultural measure, to minimize losses from this pest, especially in seed maize production. Vegetation season 2012 had on the average 48.8 mm of rainfall per month which is by 46.6 mm below the 2013 (85.16 mm) and 13.61 mm compared to the 1961-1990 data (62.41 mm) (Table 1).

Table 1. Climate conditions in vegetation season 2012 and 2013 and 30-years mean

Tablica 1. Klimatski uvjeti u vegetacijskom periodu za 2012. i 2013. godinu i 30-godišnji prosjek

Month *Mjesec*	Precipitation (mm) *Oborine (mm)*			Temperature (°C) *Temperatura* (°C)		
	2012	2013	1961-90	2012	2013	1961-90
April	47.3	42.3	54.1	12.5	13.5	11.3
May	93.5	136.0	58.9	16.9	17.2	16.5
June	67.9	57.3	83.5	22.5	20.4	19.4
July	47.8	44.8	66.6	24.8	23.7	21.1
August	4.0	87.1	59.6	24.1	23.5	20.3
September	32.3	143.5	51.8	18.9	16.1	16.6
Total *Ukupno*	292.8	511	374.5	119.7	114.4	105.2
Average *Prosjek*	48.8	85.16	62.41	19.95	19.06	17.5

As shown in Table 2, irrigation treatment has increased ear weight but decreased tunnel length, number of larvae in stem and total number of larvae in plant. Only the number of larvae in ear shank and ear shank damage were higher in A3 variant compared to the control variant (A1). A3 irrigation level had less damage on maize plants compared to A2. Very high ($P<0.05$) differences were found between irrigation variant (A2 and A3) for tunnel length (A2 – 46.77, A3 – 40.72) and number of larvae in maize stem (A2 – 2.24, A3 – 2.02). This data suggest that higher level of irrigation decreases ECB attack. In spite of these results some other authors got different results, showing that irrigation treatments increased corn borer attack (Huberty and Denno, 2004; Sharma et al., 2005). Nitrogen fertilization increased all the tested variables. According to several authors maize plants with higher level of nitrogen are more susceptible to ECB (Martin et al., 1989; Altieri and Nicholls, 2003; Zhong-Xian et al., 2007; Sarajlić et al., 2014). There were also found differences among the tested genotypes. Among all tested genotypes C1 genotype was the most susceptible to ECB injury in our study (TL, LS and TNL) (Raspudić et al., 2003; Raspudić et al., 2010).

Table 2. Impact of irrigation, nitrogen fertilization and genotype on the tested variables (2012-2013)

Tablica 2. Utjecaj navodnjavanja, dušične gnojidbe i genotipa na testirane varijable (2012.-2013.)

	EW	TL	LS	LES	TNL	ESD
A1	246.41 c	57.04 a	2.37 a	1.19 a	3.56 a	2.09 a
A2	277.53 b	46.77 b	2.24 a	0.19 a	2.44 b	1.99 a
A3	300.14 a	40.72 c	2.02 b	0.21 a	2.24 b	2.27 a
B1	229.54 a	36.91 a	1.81 a	0.16 a	1.98 a	2.04 a
B2	282.24 b	51.83 b	2.31 b	0.17 a	2.48 a	1.99 a
B3	312.16 c	55.75 b	2.51 b	1.27 b	3.79 b	2.32 a
C1	277.05 a	57.58 a	2.72 a	0.21 a	2.94 a	2.44 a
C2	280.26 a	45.01 b	2.20 b	0.21 a	2.41 b	2.09 a b
C3	282.07 a	44.96 b	2.10 b	0.18 a	2.28 b	2.31 a
C4	259.40 a	45.14 b	1.83 c	1.53 b	3.36 c	1.62 b

EW – ear weight, TL – tunnel length, LS – larvae in stalk, LES – larvae in ear shank, TNL – total number of larvae, ESD – ear shank damage; Values with different letters in the same column are significantly different at the 0.05 probability level

Influence of the year on nitrogen content in maize leaf for all treatments in experiment is shown in Table 3. Nitrogen content of leaf was similar in variants with irrigation and nitrogen fertilization. Variant within one treatment statistically differ at 0.05. Variant A3 under irrigation treatment and B3 under fertilization treatment had the highest nitrogen content in maize leaf (2.92 and 2.93) in 2012. In 2013 variant A2 and B3 had the highest nitrogen content (2.37 and 2.61). In 2012, C1 and C2 genotype statistically differed at 0.05 compared to other two, but in 2013 there were no statistically differences between genotypes in nitrogen leaf content.

Table 3. Influence of the year (2012-2013) on nitrogen content in maize leaf for all treatments in the experiment

Tablica 3. Utjecaj godine (2012.-2013.) na sadržaj dušika u listu kukuruza po tretmanima

	A1	A2	A3	B1	B2	B3	C1	C2	C3	C4
2012	2.67 c	2.81 b	2.92 a	2.67 c	2.80 b	2.93 a	2.70 b	2.69 b	2.87 a	2.95 a
2013	2.20 a	2.37 a	2.29 a	1.78 b	2.47 a	2.61 a	2.27 a	2.17 a	2.36 a	2.35 a

A1- control, A2 from 60% to 80% FWC and A3 from 80% to100% FWC; B1-0, B2-60 and B3-120 kg N/ha; C1 - OSSK 596; C2 - OSSK 617; C3 - OSSK 602 and C4 - OSSK 552; Values with a different letters in the same row are significantly different at the 0.05 probability level

Correlation coefficients between tested variables can be found in Table 4. Nitrogen leaf content did not show strong correlation with the other tested variables. The strongest correlation has been found between the number of larvae in the stem and total number of larvae per plant (0.889). Also, statistically significant but moderate positive correlation was between tunnel length and number of larvae in stem (0.486), tunnel length and total number of larvae (0.455) and total number of larvae and larvae in ear shank (0.451). Correlation between ear weight and nitrogen leaf content was weak positive but statistically very significant (0.237). There was moderate positive correlation between nitrogen leaf content and tunnel length and statistically very significant (0.317).

Table 4. Correlation coefficient between the tested variables

Tablica 4. Koeficijent korelacije između testiranih varijabli

	EW	TL	LS	LES	TNL	ESD	N leaf
EW	1.000						
TL	-0.003	1.000					
LS	-0.004	0.486**	1.000				
LES	0.044*	0.029	0.031	1.000			
TNL	0.014	0.455**	0.889**	0.451**	1.000		
ESD	0.059**	0.113**	0.151**	0.322**	0.224**	1.000	
N leaf	0.237**	0.317**	0.132	-0.115	0.106	0.039	1.000

EW – ear weight, TL – tunnel length, LS – larvae in stalk, LES – larvae in ear shank, TNL – total number of larvae, ESD – ear shank damage, N leaf – nitrogen leaf content; *Correlation is significant at the 0.05 level; **Correlation is significant at the 0.01 level

CONCLUSION

These results suggest that good agricultural practices can significantly affect the susceptibility of maize to ECB. Irrigation treatment increased yield but decreased tunnel length, number of caterpillars in stem and total number of caterpillars in plant. Maize plants in A1 (non-irrigated) variant were the most sensitive to the ECB attack. Nitrogen fertilization increased all the tested variables so we recommended B2 level because of satisfactory yield and cost effectiveness. Among the studied genotypes, genotype C1 was the most susceptible of ECB feeding and C3 was the most tolerant. Nitrogen leaf content didn't show strong correlation with tested variables but ear weight and tunnel length were statistically significant in correlation with nitrogen leaf content.

Correlations between ear weight, tunnel length and number of larvae in maize stem were also positive and statistically significant.

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POVEZANOST ISHRANE KUKURUZNOGA MOLJCA SA SADRŽAJEM DUŠIKA U LISTU U SKLOPU RAZLIČITE POLJOPRIVREDNE PRAKSE

SAŽETAK

Jedan od najznačajnijih štetnika na kukuruzu je kukuruzni moljac (Ostrinia nubilalis Hübner) (ECB). Cilj ovog istraživanja bio je utvrditi utjecaj navodnjavanja, dušične gnojidbe, različitih genotipova i sadržaja dušika u listu kukuruza na ishranu kukuruznog moljca. Pokus je postavljen u Osijeku, Hrvatska, u poljskim uvjetima, tijekom vegetacijske sezone 2012.-2013. Tretmani pokusa su sljedeći: tri razine navodnjavanja (A1 – kontrola, A2 – 60%-80% poljskoga vodnoga kapaciteta-PVK i A3 - 80%-100% PVK), tri razine dušične gnojidbe (B1 – 0 kg N/ha, B2 - 100 kg N/ha i B3 - 200 kg N/ha) i četiri genotipa (C1 - OSSK 596; C2 - OSSK 617; C3 - OSSK 602 i C4 - OSSK 552). Ocjenjivana svojstva bila su: masa klipa, broj ličinki u stabljici i dršci klipa, dužina oštećenja te sadržaj dušika u listu kukuruza. Genotip C1 bio je najosjetljiviji za ispitivane varijable: dužinu oštećenja (TL), broj ličinki u stabljici (LS) i ukupan broj ***ličinki po biljci (TNL), na razini značajnosti P<0,05. Povećavajući razinu navodnjavanja, smanjuje se zaraza kukuruznim moljcem, dok se podizanjem razine dušične gnojidbe zaraza povećava. Ti rezultati ukazuju da se dobrom poljoprivrednom praksom može značajno utjecati na osjetljivost kukuruza na kukuruznoga moljca.***

Ključne riječi: kukuruzni moljac, gnojidba dušikom, genotip, navodnjavanje

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