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RESEARCHES CONCERNING EUROPEAN CORN BORER (*Ostrinia nubilalis* Hbn.) CONTROL, IN SOUTH-EAST OF THE ROMANIA

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Abstract

European corn borer (Ostrinia nubilalis Hbn) is one of the most important maize pests in Romania, especially in the central and western region of the country, in hilly areas and along the main rivers, in the Danube flooded plains. However, in last years, ECB produce high damages at maize crops in south and south-east of the Romania, too. In this paper there were presented results of a study concerning both chemical and biological control of this pest at maize crop, between 2016 and 2018, in the climatic conditions from south-east of the Romania. The experiences were carried out at NARDI Fundulea, Calarasi County. Five days before foliar spraying, maize plants were artificial infested witch ECB egg batches produced in laboratory conditions, from insects reared consecutive generations, using same artificial diet. Climatic conditions from first 15 days of July, when it has made artificial infestation of the maize plants were favourable for ECB attack in all studied years. As result, the attack of this pest at maize untreated plants was high. Foliar application of both, chemical and biological insecticides, provide effective protection of the maize plants, against ECB larva attack, in first week after the treatments. However, in the climatic conditions of the years 2016 and 2017, at treated variants, it has observed highest amount of ECB larva/plant, at assessment made in autumn, comparative with first assessment made at 5 days after the treatments.

Key words: *maize, borer, control, artificial, infestation.*

INTRODUCTION

Maize is one of the most important crops in Romania (Soare & Dobre, 2016; Tudor et al., 2017; Popescu A., 2018). According Eurostat reports, in 2018, our country occupied first place in EU, both for maize area and yield. However maize production per hectare, realized in Romania is lower, comparative with countries from Western Europe (Eurostat data, 2015; 2016; 2017). The main reasons for maize yield losses in Romania are because of drought (Stan & Naiescu, 1997; Sabau et al., 2002; Bonea & Urechean, 2011; Panaitescu et al., 2012; Ion et al., 2013; Cociu & Cizmas, 2015; Vizitiu et al., 2016), low temperatures during emergence period (Elena et al., 2011; Has et al., 2012; Rusu & Moraru, 2015; Balas-Baconschi et al., 2019), high temperatures during flowering period (Cuculeanu et al., 1999; Mateescu & Alexandru, 2010; Cociu et al., 2012: Pravalie et al., 2017), weeds (Bogdan et al., 2007; Borza et al., 2009; Stanila et al., 2013; Rusu et al., 2015), diseases and pests attack (Muresan & Mustea, 1995; Popov, 2002; Meiselle et al., 2010; Antonie et al., 2012; Ivas & Muresan, 2013; Georgescu et al., 2016; Trotus et al., 2018). According Trotus et al. (2011) only because of the pest attack, maize yield losses can arrive at 23%. In the climatic conditions from Romania, the main pests of the maize crop are wire worms (*Agriotes* spp.), maize leaf weevil (*Tanymecus dilaticollis*), european corn borer (*Ostrinia nubilalis*), western corn rootworm (*Diabrotica virgifera virgifera*), corn earworm (*Helicoverpa armigera* sin. *Chloridea obsolete*) and other species from *Noctuidae* family (Popov et al., 2001; Popov & Barbulescu, 2007; Rosca & Istrate, 2009; Trotus et al., 2013; Manole et al., 2017). European corn borer (*Ostrinia nubilalis*) it is one of the main pests of the maize crops from Romania (Paulian et al., 1976; Barbulescu et al., 1988; Mustea, 1990; Rosca & Barbulescu, 1997; Popov et al., 2005; Trotus et al., 2017). According Cristea et al. (2004), favorable areas from this pest are located in western and central part of the country (Transylvania) in hilly areas and along the main rivers or in the Danube flooded plains. Same author mentioned that in south and south-east, ECB is second pest like economic importance, after maize leaf weevil (*Tanymecus dilaticollis*). According data from the literature, in Romania, maize yield losses, because of ECB attack, can arrive at 60% (Paulian et al., 1976). In the middle of the years ’70, Sapunaru and Hartman (1975) reported maize yield losses from 1400 to 2360 kg/ha, in different farms from east of the country. In Transylvania, at the beginning of the years ’80, Mustea (1981) reported maize yield loses from 5.4 to 9.8%. More recent data, suggest that average maize yield losses in Romania, because of ECB attack were 7.5% (Popov & Rosca, 2007). After 2000, it hasn’t reported important maize yield loses as result of ECB attack. However, after 2010, in journals for farmers it has reported higher attack of this pest at maize crops in western part of the country (Alexandri A., 2011; Plants Health, 2012; Farm, 2013). In last years, it has registered high attack of ECB in south-east of the Romania, too (Georgescu et al., 2016). Possible explication for this situation is because of the climatic changes that can favor insect in first stages of development (Olesen et al., 2011). Same author mentioned that climates changes from the Central and South-East Europe countries can have negative impact on local agriculture and, in same time, can favor pests attack. Researches for control of ECB attack in Romania it was made at NARDI Fundulea (for south-east of the country) and ARDS Turda (for central part of the country). ECB larva was reared on laboratory conditions, using same artificial diet for obtain egg-batches used for artificial infestation of the maize plants (Barbulescu, 1977; 1978; 1979; 1980). The purpose of these researches was to evaluate reaction of the maize inbreed lines and hybrids at ECB larva attack (Barbulescu et al., 1985; 1999; 2001; Barbulescu & Cosmin, 1987; 1997; Mustea, 1990), effectiveness of the foliar treatments in controlling of this pest (Barbulescu, 1989; Muresan & Mustea, 1995; Rosca & Barbulescu, 1997; Georgescu et al., 2016) and biological control effectiveness against this pest (Rosca & Barbulescu, 1986). Now days, only at NARDI Fundulea continue the activities concerning rearing of ECB larva, in laboratory conditions, consecutive generations using same artificial diet. As result of increasing of the area cultivated with maize, and higher attack of ECB larva, new researches are necessary, concerning control of this pest. In this paper, author collective present results concerning effectiveness of both, chemical and biological control of the ECB larva, at maize crops, in conditions of artificial infestation of the maize plants with ECB egg batches, in south-east of the Romania.

MATERIALS AND METHODS

The experiment was carried out at the experimental field of the Plants and Environment Collective, from National Agricultural Research Development Institute (NARDI) Fundulea, Calarasi County, Romania (44° 30′ N, 24° 1′ E). Experimental plots were arranged according randomized blocks design, each variant has four replications. Maize plants were sowed in plots, 10 m length and 4.2 m width (six rows) that correspond on an area of 42 m. For this experiment it has used Olt maize hybrid (FAO 450). In 2016, maize was sowing on 19 April, in 2017 maize was sowing on 18 May while in 2018 maize was sowing on 25 April. Because of high amount of rains occurred in April, 2017, it has registered a delay of sowing maize, approximate 4 weeks, comparative with normal period. Also, as result of drought registered in April, and first 10 days of May in 2018, most of the maize plants emerged after 20 May.

Table 1. Active ingredients used in research concerning effectiveness of ECB larva control, at NARDI Fundulea (2016-2018)

Variant no.	**Active ingredient** (concentration)	**Rate** (ml, g c. p./ha)
1	control (untreated)	-
2	deltamethrin (100 g/l)	75
3	lambda-cihalothrin (50 g/l)	150
4	indoxacarb (150 g/l)	250
5	chlorantraniliprole (20 %)	250
6	*B. thuringiensis* (54 %)	500
7	*B. thuringiensis* (54 %)	750
8	*B. thuringiensis* (54 %)	1000

Active ingredients used in this study were listed on Table 1. From pyrethroid class it has tested deltamethrin and lambda-cihalothrin active ingredients, from oxidazyne class it has tested indoxacarb active ingredient while from ryanoid class it has tested chlorantraniliprole active ingredient. Also it has tested a formulation on a base of *B. thuringiensis* subsp. *kurstaki* (ABTS-351 strain), used for biological control of the pests (Roh et al., 2007). In this study it has tested three doses of this formulation (500, 750 and 1000 g commercial product/ha).

The experiment was carried out in conditions of artificial infestation. Five days before foliar spraying, maize plants were infested with 10 egg batches/plant. Egg-batches used for artificial infestation are in "black-head" stage, when larva head become visible. From each experimental plot it has infested 40 plants. Plants were infested with ECB egg batches produced in the laboratory conditions, on continuous flux, after a technology described by Barbulescu (1980). Egg batches were placed with a tweezer at maize leaf base, from upper part of the plants (Figure 1). Attack level of the ECB larva at maize plants were analyzed both, in summer, at five days after foliar spraying (July) and in autumn (September), before harvesting (BBCH 99).

Figure 1. Artificial infestation of the maize plants with ECB egg batches, produced in laboratory conditions, at NARDI Fundulea

For these assessments, the stalk of the maize plants, that were artificial infested, before foliar spraying, was cooped in twice. During summer assessments it has determined the number of larva/plant and the number of holes/plant. During autumn assessments it has determined the number of alive ECB larva/plant and cavities length (cm) per plant. Also, at summer assessment, it has determined ECB attack incidence (%).

Meteorological data were collected from automatic meteo stations (iMethos), placed in the experimental field. It has registered average air temperature (°C) and rainfalls amount. This data was recorded every hour.

The data were **statistical analyzed** using Student-Newman-Keuls (SNK) test for multiple comparisons used to identify sample means that are significantly different from each other (Student, 1927; Neuman, 1939; Keuls, 1952).

RESULTS AND DISCUSSIONS

Climatic conditions from period that were made artificial infestation of the maize plants with ECB egg batches are very important. High temperatures and drought has result of higher mortality percent of ECB first instars larva and low percentage of larva eclosion (Paulian et al., 1976; Barbulescu et al., 2001). Same author mentioned that heavy storms registered in this period can have negative effect on population dynamic, of this pest. However, if air temperature is moderate and air humidity is high can result an increasing of larva eclosion percentage and lover mortality percent of 1st instar larva (Rosca & Rada, 2009).

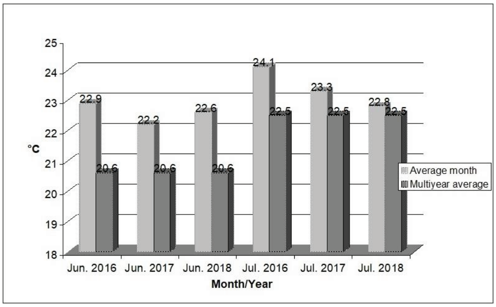

Figure 2. Average air temperature registered in June and July, period 2016-2018, at NARDI Fundulea

During this experiment, at NARDI Fundulea, in 2016, artificial infestation of the maize plants were made on 5 July and foliar treatments on 10 July, in 2017, artificial infestation were made on 8 July and foliar treatments on 13 July while in 2018, artificial infestation were made on 1 July and foliar treatments on 6 July.

Data recorded at meteorological stations from experimental field of NARDI Fundulea, reveal that, in summer period, between 2016 and 2018, average air temperature registered in June and July was higher then multiyear average (Figure 2). Higher deviation from the multiyear average was recorded, both in June and July, 2016 (+2.3 and +1.6°C). Also, in June, 2018, it has recorded high deviation of the average temperature recorded in this month, comparative with multiyear average (+2.0°C).

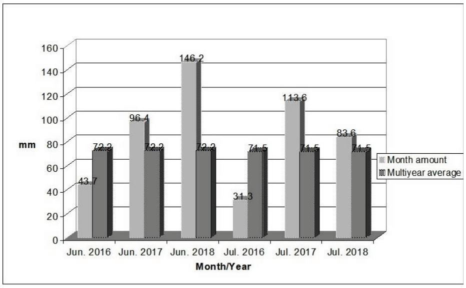

Figure 3. Rainfalls amount registered in June and July, period 2016-2018, at NARDI Fundulea

However, deviation of the average monthly temperature comparative with multiyear average was higher in June comparative with July, in all studied years.

Regard as rainfall amount, registered at automatic meteo station, from experimental field of NARDI Fundulea, in June and July, between 2016 and 2018, it has ascertained higher variability of this parameter (Figure 3). In 2016, rainfalls amount registered in June and July was below multiyear average while in 2017 and 2018 was higher than averages. Higher deviation from the average was recorded in June, 2018 (+74.0 mm).

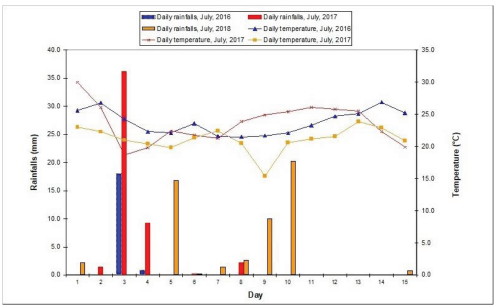

Figure 4. Daily temperatures and rainfalls recorded in first 15 days of July, between 2016 and 2018, at NARDI Fundulea

Daily temperatures and rainfalls amount are very important for ECB population dynamic. The most sensitive stage of this pest to weather conditions is during egg laying stage-larva eclosion-larva 1st instars. In 2016, daily rainfalls distribution and temperatures evolution, in first 15 days of July, was favorable for ECB larva (Figure 4). High rain amount has occurred two days before artificial infestations, as result the air humidity were favorable for larva eclosion. Similar situation was recorded in first 15 days of July, 2017. Between 3 and 4 July, it as registered 45.4 mm of rain, as result air humidity at 8 July, when it has made artificial infestation of maize plants with ECB egg batches were favorable for larva eclosion. Rainfalls amount registered in first 15 days of July, 2018 was high. After artificial infestation, on 1 July it has recorded 2.2 mm of rain. Between 5 and 10 July, 2018, it has recorded 51.2 mm of rains and moderate temperatures. However, temperatures recorded in first 48 hours after artificial infestation, were high and air humidity was low, that represent less favorable conditions for larva eclosion.

Table 2. Effectiveness of some active ingredients used in controlling of the *O. nubilalis* larva attack, at NARDI Fundulea, summer assessments (July)

Active ingredient	Rate (ml, g c. p./ha)	Attack incidence (%)			Number of larva/plant		
		2016	2017	2018	2016	2017	2018
control (untreated)	-	100 A	100 a	62.50 a	14.75 a	13.80 A	2.05 S
deltamethrin	75	86.25 Ab	86.25 b	3.75 b	7.95 b	5.20 B	0.08 B
lambda-cihalothrin	150	92.50 Ab	68.75 c	21.25 b	7.79 b	4.80 Bc	0.23 B
indoxacarb	250	97.50 A	85.00 b	13.75 b	6.08 b	3.10 C	0.15 B
chlorantraniliprole	250	67.50 C	67.50 c	21.25 b	7.75 b	3.45 Bc	0.45 B
B. thuringiensis	500	78.75 Bc	82.50 bc	13.75 b	7.55 b	4.33 Bc	0.35 B
B. thuringiensis	750	77.50 Bc	78.75 bc	11.25 b	5.95 b	4.05 Bc	0.28 B
B. thuringiensis	1000	75.00 Bc	76.25 bc	10.00 b	5.93 b	3.85 Bc	0.15 B

*Means followed by same letter or symbol do not significantly differ (P = 05, Student-Newman-Keuls)

In Table 2 there were presented results of assessments made in summer, at 5 days from foliar spray and 10 days from artificial infestation of maize plants with ECB egg batches. Regard as attack incidence of *O. nubilalis*, at five days after foliar spraying, it can have ascertained that, in climatic conditions of the years 2016 and 2017, at untreated variant, value of this parameter was maximum (100%). In 2016, at treated variants, attack incidence of the ECB larva at maize plants, ranged from 67.50 to 97.50% while in 2017, attack incidence of this pest, at treated variant, ranged from 67.50 to 86.25%. Lower values of the attack incidence it has registered in 2018, at all experimental variants. Regard as number of larva/plant, at five days after foliar spraying, data from Table 2 reveal that, at untreated variant, in 2016 it has registered 14.75 larva/plant while, one year later, at same variant, it has registered 13.80 larva/plant. However, in 2018, at control (untreated) variant it has registered only 2.05 larva/plant. In the climatic conditions of the years 2016 and 2017, in conditions of a heavy infestation pressure, and favorable climatic conditions for pest development, foliar spraying of the maize plants with, both chemical and biological insecticides, provide effective protection against this pest, in first days after treatments. Same results were observed in conditions of the year 2018, when it has registered low pest pressure, especially because unfavorable climatic conditions, after artificial infestation of the maize plants with ECB egg batches, produced in laboratory conditions.

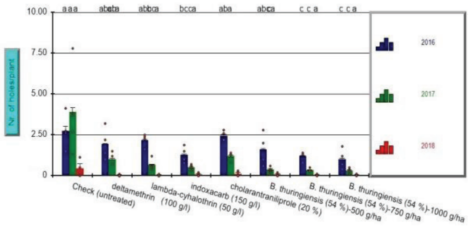

Figure 5. Number of holes/plant, at five days after foliar spraying (NARDI Fundulea, 2016-2018)

In all three years of this experiment, at five days after foliar spraying it has ascertained that there were significant statistic differences between biological products on a base of *B. thuringiensis* subsp. *kurstaki* (ABTS-351 strain) and untreated variant, concerning both, attack incidence and number of ECB larva/plant. However, there weren't statistical differences between the three doses of this biological product (p<.05). Concerning of ECB attack incidence, at five days from foliar treatment, according Student-Newman-Keuls (SNK) test, highest statistical differences comparative with untreated variant it has registered in case of chlorantraniliprole active ingredient, in 2016 and 2017. In the climatic conditions of 2018, there weren't registered statistical differences between treated variants, both with chemical and biological insecticides. Using SNK test, it has ascertained that, concerning number of larva/plant, in conditions of the high pest pressure from 2016 and low pest pressure in 2018, there weren't statistical differences between treated variants and control (untreated) variant (p<.05), while in 2017, highest statistical differences, comparative with untreated variant it has registered in case of indoxacarb active ingredient.

Table 3. Effectiveness of some active ingredients used in controlling of the *O. nubilalis* larva attack, at NARDI Fundulea, autumn assessments (September)

Active ingredient	Rate (ml, g c. p./ha)	Cavities length/plant (%)			Number of larva/plant		
		2016	2017	2018	2016	2017	2018
control (untreated)	—	20.25 A	36.18 a	24.33 a	12.63 a	12.32 a	4.45 a
deltamethrin	75	8.33 b	22.35 a	18.68 ab	5.50 b	9.63 abc	2.93 b
lambda-cihalothrin	150	8.31 b	19.50 a	14.43 b	5.70 b	8.18 abc	2.65 b
indoxacarb	250	8.22 b	18.94 A	19.03 ab	4.50 b	7.58 bc	2.75 b
chlorantraniliprole	250	5.30 c	12.11 C	4.88 c	4.01 b	6.51 c	1.03 c
B. thuringiensis	500	8.88 b	25.08 B	18.90 ab	5.93 b	12.29 a	3.08 b
B. thuringiensis	750	8.44 b	24.68 B	16.98 ab	5.60 b	11.75 ab	3.10 b
B. thuringiensis	1000	7.81 b	23.53 B	16.70 ab	5.40 b	10.72 abc	2.96 b

*Means followed by same letter or symbol do not significantly differ (P=.05, Student-Newman-Keuls)

Similar situation it has registered in case of holes number/plant, made by ECB larva, in climatic conditions of the years 2017 and 2018 (Figure 5). However, in 2016, highest statistical differences comparative with control variant, it has registered in case of last two doses of biological insecticide, on base of *B. thuringiensis* (750 and 1000 g c. p./ha).

In Table 3 there were presented results of assessments made in autumn, before harvest. In the climatic conditions of the year 2016, it has ascertained that cavities length/plant, at untreated variant was 20.25 cm. At treated variants this parameter ranged between 5.30 and 8.88 cm. According SNK test, highest statistical difference comparative with untreated variant it has registered in case of variant treated with chlorantraniliprole (p<.05). In conditions of the year 2017, at all experimental variants it has registered high values of the cavities length/plant. At maize plants from control (untraded) variant, cavities length/plant was higher than 36 cm. Higher statistical differences comparative with untreated variant it was registered in case at chlorantraniliprole variant. Similar situation it has recorded in conditions of the year 2018.

Concerning number of the larva/plant, in autumn, when maize plants are in BBCH 99 stage, assessments results reveal that, in 2017 and 2018, at all treated variants, number of larva/plant was higher comparative with summer period (at five days from foliar spray). A possible reason for this is because of attack of natural population of ECB or appearance of a new generation of this pest, in the climatic conditions from south-east of the Romania. According SNK test, it has ascertained that, there weren't statistical differences between all treated variants, concerning number of larva/plant. In same time the differences between treated variants and control (untreated) variant were significant ($p<.05$). In conditions of 2017 and 2018, highest statistical differences comparative with untreated variants, it has registered in case of variant treated with chlorantraniliprole active ingredient ($<.05$).

In conditions of high pest pressure as result of artificial infestation, at NARDI Fundulea, foliar treatment with, both chemical and biological insecticides provide effective protection of the maize plants, against this pest, first five days after treatments. However single foliar treatment didn't provide effective protection of the maize plants, until the end of the vegetation period, in autumn.

CONCLUSIONS

Rearing of the European corn borer (*Ostrinia nubilalis* Hbn.), consecutive generations, in laboratory conditions, using same artificial diet is a good method to evaluate effectiveness of the insecticides applied like foliar spraying for control this pest.

Climatic conditions from summer period, registered at NARDI Fundulea were favorable for ECB larva development in 2016 and 2017 and less favorable in summer of the 2018.

In the conditions of artificial infestation of the maize plants, with ECB egg batches, foliar spraying assign effective protection of the maize plants against pest attack only in summer period.

In this experience, between 2016 and 2018, in the climatic conditions from south-east of the Romania, highest effectiveness in control of this pest was registered in case of chlorantraniliprole active ingredient.

Between 2016 and 2018, in the climatic conditions from south-east of the Romania, biological insecticide on a base of *B. thuringiensis* subsp. *kurstaki* (ABTS-351 strain) can provide effective protection for maize plants against ECB larva.

Further studies are necessary to evaluate impact of the climatic changes on ECB populations dynamic in Romania.

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