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RESEARCHES CONCERNING THE EFFECTIVENESS OF THE MAIZE LEAF WEEVIL CONTROL (*Tanymecus dilaticollis* Gyll), IN THE COMMERCIAL FARM CONDITIONS, FROM THE SOUTH-EAST OF ROMANIA

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Abstract

Maize leaf weevil (Tanymecus dilaticollis Gyll) is one of Romania's most harmful pests of maize crops. The purpose of this study is to evaluate the effectiveness of the different control methods of the maize leaf weevil in conditions of the high pest pressure from a commercial farm, located in one of the most favorable areas for this weevils species, in the southeast of Romania (Mihail Kogălniceanu, Ialomița County). This study has tested foliar treatment with acetamiprid and lambda-cyhalothrin active ingredients, seeds treatment with imidacloprid and cyantraniliprole active ingredients, and granules application with the lambda-cyhalothrin active ingredient. In the spring of 2021, at the experimental site, it has registered a high pest density (15-20 weevils/m^2). As a result of the weather's unfavorable conditions for weevils activity on the ground, the pest attack was moderate when maize was in early vegetation stages. At the control (untreated) variant, most of the maize plants had leaves chaffed in the proportion of 50-75%, but the majority of the plants survived after the attack. In this study, lower weevils attack has registered in the case of the variants with seeds treated with imidacloprid and cyantraniliprole active ingredients. From all experimental variants, higher maize yield was recorded in the case of the variant with seeds treated with imidacloprid active ingredient (12501 kg/ha). This study, effectuated in conditions of high pest pressure, in commercial farm conditions, demonstrates that seed treatment with systemic insecticides adequately protects the maize plants in early vegetation stages (BBCH 10-BBCH 14) against maize leaf weevil attack.

***Key words**: maize, weevil, farm conditions, control.*

INTRODUCTION

Maize leaf weevil (*Tanymecus dilaticollis* Gyll) is a polyphagous pest; that belongs to the Curculionidae family (Coleoptera order). The literature has mentioned that these weevils attacked more than 70 host plants (Čamprag, 1963; Čamprag et al., 1969; 2006; Paulian, 1972; Popov and Bărbulescu, 2007). However, the insects from this specie have preferences for maize and sunflower plants (Paulian et al., 1979; Voinescu, 1985; Popov, 2002; Popov et al., 2005; Bărbulescu et al., 2001b; Georgescu et al., 2014; Trotuș et al., 2019). If the attack occurs when these crops are in the first vegetation stage (BBCH 10-BBCH 14), weevils can destroy young plants, and farmers must sow again (Čamprag et al., 1969; Paulian, 1972; Bărbulescu et al., 2001b). Drought and high temperatures recorded during the first vegetation stages of the primary host plants favored weevils attack (Popov et al., 2006). Data from the literature suggest that maize monoculture; for several years have consequence increasing the maize leaf weevil's population in the following years and high yield losses as a result of this pest attack (Bărbulescu and Voinescu, 1998; Voinescu and Bărbulescu, 1998; Popov and Bărbulescu, 2007). A possible explication for this is because maize roots provide optimum conditions for larva development (Paulian, 1972; Boguleanu et al., 1980; Roșca and Istrate, 2009). As a result, maize plants provide better conditions for the entire biological life cycle of the *T. dilaticollis*. The same authors mentioned that, from the wild plant's species, creeping thistle (*Cirsium arvense*) roots provide optimum conditions for larva development while leaves offer good conditions for the adults feeding. According to the data from the literature, in Romania, every year there were attacked by maize leaf weevil (*T. dilaticollis*) one million hectares cultivated with maize and one half million hectares cultivated with sunflower (Bărbulescu et al., 1991; 1993; 1995; Bărbulescu, 2001; Popov, 2002; 2003; Popov et al., 2005; 2007a; Popov and Bărbulescu, 2007). Early data from the Romanian literature mentioned average maize yield losses of 34% at a pest density of 25-30 weevils/m^2 (Paulian, 1972). The same author noted that the economic damage threshold for this specie is five weevils/m^2. More recent data from the Romanian literature report higher densities of this pest in the favorable areas in south and south-east of Romania, ranging from 15 to 80 weevils/m^2 (Bărbulescu et al., 1991; 1993; 1995; Bărbulescu, 2001; Popov et al., 2005; 2007a). In our previous research, conducted in conditions of a commercial farm located in an area with high pest pressure (25-30 weevils/m^2), untreated maize plants were destroyed by the weevils (Georgescu et al., 2018). At the same time, Badiu et al. (2019) report a reduction of the maize density by 25-50% due to this pest attack in the south, southeast, and east of Romania. Seed coating with systemic insecticides, with rapid translocation of the active ingredients in the plants, after the emergence, was the most effective method of controlling maize leaf weevils in Romania and neighbored countries (Voinescu, 1985; Bărbulescu et al., 1993; 2001b; Vasilescu et al., 2005; Popov and Bărbulescu, 2007; Čamprag, 2007; Popov et al., 2006; 2007b; Keszthelyi et al., 2008; Trotuș et al., 2011; 2019; Georgescu et al., 2021b). According to European Commission regulations 218/783, 218/784, and 218/785, imidacloprid, clothianidin, and thiamethoxam active ingredients were banned in the European Union, both for seed and foliar treatments, starting from 2019. As a result, no insecticides remain available for maize seed treatment for controlling the *T. dilaticollis* attack in Romania. Alternatives methods such as foliar treatments, granules application, crop rotations, or early sowing data have low effectiveness in controlling the weevil's attack on maize crop compared with seed treatment with systemic insecticides, in conditions of high pest pressure, from the favorable areas located in the south and southeast of the Romania (Paulian, 1981; Bărbulescu and Voinescu, 1998; Voinescu and Bărbulescu, 1998; Georgescu et al., 2018; 2019; 2021b; Toader et al., 2020; Toshova et al., 2021). Because of a lack of effective alternatives to controlling the maize leaf weevil, between 2014 and 2022, Romania has granted temporary authorization for maize seed treatment with neonicotinoids for controlling the *T. dilaticollis* attack in spring. Moreover, from 2013 to 2019, the whole EU has granted 206 temporary authorizations to use neonicotinoids as active ingredients for seed treatment and foliar application to field crops or sugar beet (Abnett, 2021). Meissle et al. (2010) mentioned that maize leaf weevil is a regional pest in European Union, being localized in south-east of the continent. However, because of the higher level of the maize leaf weevil population recorded in Romania, especially in the favorable areas of this pest, the main damaging area of *T. dilaticollis* adults from EU27 is in Romania. The lack of alternatives for seed treatment can harm Romanian maize growers and can have negative economic consequences for this country (Ionel, 2014). In the absence of seed treatment, the maize growers will use foliar spray with pyrethroid active ingredients, for controlling pests attack, with a negative impact on the environment (Kathage et al., 2018). The present study aimed finding of possible alternatives for maize seeds treatment with imidacloprid active ingredient, for controlling the maize leaf weevils, in high pest pressure condition, from a commercial farm located in south-east Romania.

MATERIALS AND METHODS

The field trial were carried in 2021, at the commercial farm Sopema SRL, located at Mihail Kogălniceanu, Ialomița County, Romania (latitude: 44°42'N, longitude: 27°40', altitude: 18 m a.s.l). This location is placed in the favorable area of *T. dilaticollis* in south-east of Romania. In this trial it has assessed seed treatment with cyantraniliprole (625 g/l) active ingredient from diamid class, foliar application with acetamiprid (20 %), from neonicotinoid class and lambda-cyhalothrin (50 g/l) active ingredient from pyrethroid class. Also, it has assessed granules application with lambda-cyhalothrin (4 g/kg) active ingredient, from pyrethroid class. These variants were compared with standard treatment of maize seeds with imidacloprid active ingredient, from neonicotinoid class, that was banned according to EU relegations, but in Romania it has granted temporary authorization for spring of 2021 (Table 1). The intensive technology presented bellow is specific for commercial farms from this area (south-east of Romania). Maize were sowed on 26 April, full plants emergence was on 5 May. It has used Kashmir maize hybrid (FAO 370) at a density of 78000 seeds/ha and 75 cm distance between rows. Maize was sowed after maize, for having a high pest pressure. One day before sowing it was applied liquid fertilizer UAN (32% N) on dose of 230 l commercial product/ha. In same time with sowing, it has applied micro granules fertilizer (NPK 10:40:40) in dose of 240 kg c.p./ha.

Table 1. Active ingredients used in this study

Variant no.	Commercial product name	Active ingredient	Insecticid class	Rate[1]	Type of application
1	control (untreated)	—	—	—	—
2	Mospilan 20 SG	acetamiprid (20 %)	Neonicotinoid	0.1 kg/ha	Foliar application[2]
3	Nuprid 600 FS-std.	imidacloprid (600 g/l)	Neonicotinoid	2.20 µl/grain	Seed treatment[3]
4	Lumiposa	cyantraniliprole (625 g/l)	Ryanoid	2.20 µl/grain	Seed treatment[3]
5	Ercole	lambda-cyhalothrin (4 g/kg)	Pyrethroid	12.00 kg/ha	Granules application[4]
6	Karate Zeon	lambda-cyhalothrin (50 g/l)	Pyrethroid	0.15 l/ha	Foliar application[2]

1-commercial product
2-seed treatment (before sowing, BBCH 00)
3-foliar applications (when maize was in BBCH 12-13 stage, 14.05.2021)
4-granules application at sowing (BBCH 00, 26.04.2021)

The soil from experimental site (commercial farm Sopema) is chernozem with medium texture, humus content of 1.8%, pH of 7.93, nitrogen content of 0.179%, potassium content of 29 mg/kg and phosphorus content of 208 mg/kg. For crop protection against monocotyledonous and dicotyledonous weeds, several herbicides were applied. Nine days before maize sowing (17.04.2021) it has applied Adengo 465 SC herbicide [(isoxaflutol (225 g/l) + tiencarbazon-metil 90 g/l + ciprosulfamide (safener) (150 g/l) active ingredients] in dose of 0.4 l c.p./ha. When maize crops was in BBCH 16 stage it has applied Temsa SC herbicide [mesotrione (100 g/l) active ingredient] in dose of 1.5 l c.p./ha (22.05.2021). When maize was in an advanced stage (BBCH 18) it has applied both herbicides, Cerlit Super [fluroxipir (333 g/l) active ingredient] in dose of 0.54 l c.p./ha and Samson Extra OD [nicosulfuron (60 g/l) active ingredient] in dose of 0.4 l c.p./ha (06.06.2021). For this trial the area of each experimental plot was of 2100 m^2.

Field assessments: phytotoxicity was evaluated on whole plot, when maize plants where in four leaves stage, according EPPO PP1/135 standard (EPPO standards, 2014).

Plants density it has made twice, first assessment when maize plants were in BBCH 14 stage (17.05.2021) and second assessment when maize plants were in BBCH 16 stage (28.05.2021). On each variant, it has established four assessment points. At each assessment point, it has counted maize plants from 20 row meters (80 row meters/variant). The purpose of these assessments is to see if there was a plants reduction density as result of the weevils attack.

Attack incidence of weevils at maize plants was assessed when maize was in four leaves stage (BBCH 14). At each variant, it has established four assessment points. At each assessment point it has evaluated 50 maize plants, from five rows (10 plants/row). Before assessment plants from each row were marked with sticks, in stair system. Each plant from the assessment points was photographed with Panasonic G9 photo camera, with Leica DG O.I.S. lens (12-60 mm, f 2.8/4), then images were analyzed at computer to see if there were bites produced by the weevils.

Attack intensity of weevils was assessed when maize plants were in four leaves stage (BBCH 14). Attack incidence and intensity of maize leaf weevils was assessed at the same plants. Weevils attack was rated on a scale from 1 to 9 (Figure 1), as follows:

• Note 1: plant not attacked;
• Note 2: plant with 2-3 simple bites on the leaf edge;
• Note 3: plants with bites or clips on all leafs edge;
• Note 4: plants with leafs chafed in proportion of 25 %;
• Note 5: plants with leafs chafed in proportion of 50 %;
• Note 6: plants with leafs chafed in proportion of 75 %;
• Note 7: plants with leafs chafed almost at the level of the stem;
• Note 8: plants with leafs completely chafed and beginning of the stem destroyed;
• Note 9: plants destroyed, with stem chafed close to soil level.

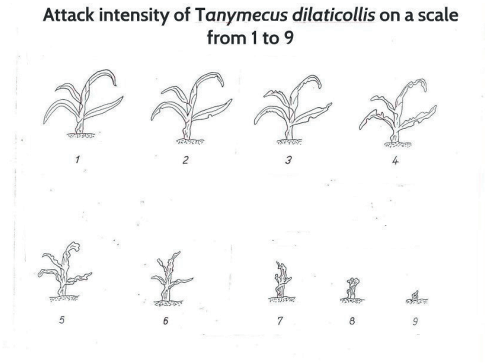

Figure 1. Attack intensity scale (Paulian, 1972, cited by Roșca and Istrate, 2009)

Maize yield were assessment at the harvest of the maize, from this trial, on 5 November, 2021. Each variant it has harvested separately. It has determined the humidity of the maize at harvest, hectoliter mass (Hgl|) and yield.
Meteorological data were collected from automatic weather station of the Sopema farm, located at 1 km from experimental site. It has monitoring daily air temperature and rainfalls amount occurred in the most sensitive stage of the maize plants at weevils attack, from emergence (BBCH 00) to four leaves stage (BBCH 14).
Statistical analysis. The results of the field trial were presented as the absolute and mean values for maize phytotoxicity, plants density on row meter, attack incidence and weevils attack intensity, the standard deviation from the average values (SD), the coefficient of variation (CV), replicate F and treatment F. The data were **statistical analyzed** using Student-Newman-Keuls (SNK) test for multiple comparisons (Student, 1927; Neuman, 1939; Keuls, 1952) using ARM software.

RESULTS AND DISCUSSIONS

At the experimental site, from Sopema Farm (Mihail Kogalniceanu, Ialomita County), the spring of the year 2021 was characterized by average air temperatures lower than multiyear average in April (with a negative deviation of 2.40°C), and May (with a negative deviation of 1.47°C). The rainfall amount recorded in April was slightly over the multiyear average, with a positive deviation of 5.9 mm. Also, it was marginally lower than the multiyear average in May, with a negative deviation of 9.9 mm. It has registered high air temperatures between night and day in the first 15 days of May. Average air temperatures registered between 5 and 7 May were below 18°C, while average temperatures during the daytime, recorded in the same period, were over 25°C. After 8 May, the minimum temperature decreased, but the maximum temperature during the day was higher than 20°C. As a result, the differences between maximum and minimum temperature were higher, and the favorable period for weevils activity during the day was shorter.

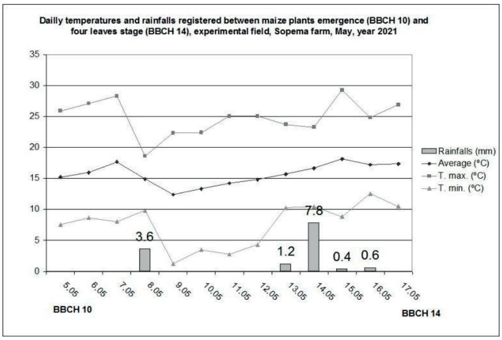

Figure 2. Daily temperatures and rainfalls recorded between maize plants emergence and four leaves stage in the spring of the year 2021 at Sopema commercial farm

Acording to Popov et al. (2006) higher temperatures and draught favored pest activity on the ground ant attack at maize plants. In this trial, as result of the unfavorable air temperatures recorded between 5 and 17 May, and high air temperature differences between night and day, that sometimes exceeded 22.00°C, the weevils activity of the ground surface, when the maize plants were most sensitive to this pest attack (BBCH 10-BBCH 14), was lower. The plants were less attacked compared with previous testing years at the same location (Georgescu et al., 2018).

Analyzing the data from Table 2 it has ascertained that there weren't phytotoxic effect at maize plants, as result of seed treatment before sowing; foliar application, when maize is in BBCH 11-12 stage, or granules application in same time with sowing. All type of the treatments with the active ingredients used in this trial, in conditions of the commercial farm, was safe for maize crop.

Table 2. Result of the phytotoxicity and plants density assessments

Variant no.	Active ingredient	Rate	Phytotoxicity (%) BBCH 14	Density (plants/row meter)	
				BBCH 14	BBCH 16
1	—	—	**0a** 0 StDev	**5.05a** 0.57 StDev	**4.78a** 1.11 StDev
2	acetamiprid (20%)	0.1 kg/ha	**0a** 0 StDev	**5.64a** 0.20 StDev	**5.31a** 0.28 StDev
3	imidacloprid (600 g/l)	2.20 µl/grain	**0a** 0 StDev	**5.78a** 0.06 StDev	**5.35a** 0.11 StDev
4	cyantraniliprole (625 g/l)	2.20 µl/grain	**0**a 0 StDev	**5.85a** 0.16 StDev	**5.51a** 0.28 StDev
5	lambda-cyhalothrin (4 g/kg)	12.00 kg/ha	**0**a 0 StDev	**5.65a** 0.21 StDev	**5.58a** 0.18 StDev
6	lambda-cyhalothrin (50 g/l)	0.15 l/ha	**0**a 0 StDev	**5.74a** 0.18 StDev	**5.40a** 0.20 StDev
LSD (p<0.05)			0	0.444	0.736
CV			0	5.250	9.180
Replicate F			0	0.466	1.162
Replicate Prob(F)			1.000	0.710	0.357
Treatment F			0	3.833	1.362
Treatment Prob(F)			1.000	0.020	0.293

Means followed by same letter do not significantly differ (p<0.05; Student-Newman-Keuls); StDev-Standard Deviation

When maize crop was in four leaves stage (BBCH 14), plants density has a slight variation, ranged from 5.05 to 5.85 plants/row meters. Also, the coefficient of variation has low value (5.25). In this stage, plants density was normal, with normal variability among the field. At the second assessment, made when maize crop was in six leaves stage (BBCH 16) it has ascertained a slight decreasing of the plants density, comparing with previous assessment. In the same time, the coefficient of variation, increasing. In both cases there weren't significant statistical differences between plants density registered at untreated variant, and plants density registered at treated variants (p<0.5). Also, it hasn't registered significant statistical differences between plants density at treated variants. However, lowest value of plant density it has registered in case of untreated variant (4.78 plants/row meter).

Regard as weevils attack incidence, in this trial, all assessed plant was attacked by this pest (Table 3). In the previous researches, in case of maize plants, attack incidence was 100 % (Georgescu et al., 2018). This situation confirms data from the literature that maize plants is the main host for maize leaf weevil.

Table 3. Result of the assessments concerning weevils attack incidence and intensity at maize plants

Variant no.	Active ingredient	Rate	Incidence (%)	Attack intensity (1-9)
1	—	—	**100a** 0 StDev	**6.92a** 0.34 StDev
2	acetamiprid (20 %)	0.1 kg/ha	**100a** 0 StDev	**6.91a** 0.53 StDev
3	imidacloprid (600 g/l)	2.20 µl/grain	**100a** 0 StDev	**5.74a** 0.15 StDev
4	cyantraniliprole (625 g/l)	2.20 µl/grain	**0a** 0 StDev	**5.66a** 0.07 StDev
5	lambda-cyhalothrin (4 g/kg)	12.00 kg/ha	**100a** 0 StDev	**6.09a** 0.90 StDev
6	lambda-cyhalothrin (50 g/l)	0.15 l/ha	**100a** 0 StDev	**6.04a** 0.91 StDev
LSD (p<0.05)			0	0.879
CV			0	9.370
Replicate F			0	1.087
Replicate Prob(F)			1.000	0.385
Treatment F			0	3.663
Treatment Prob(F)			1.000	0.023

Means followed by same letter do not significantly differ (p<0.05; Student-Newman-Keuls); StDev-Standard Deviation

In this trial, attack intensity of maize leaf weevil, on a scale from 1 to 9, ranged from 5.66 (seed treatment with cyantraniliprole active ingredient) to 6.92 (untreated variant). Most of the maize plants from this trial had leaves chaffed in the proportion of 50-75 % and some plants are complete destroyed as result of the weevils attack.

Coefficient of the variation of whole experience was 9.370. In the same time, at variants with seed treatment (imidacloprid and cyantraniliprole active ingredients) it has registered the lowest values of the standard deviation (0.15, respectively 0.07).

That means that weevils attack was uniform distributed in whole plot. At the opposite it was variants treated with lambda-cyhalothrin active imngredient, both as foliar and granules application.

Table 4. Result of the assessments concerning maize yield from this trial (Sopema farm)

Variant no.	Active ingredient	Mois-ture (%)	Hgl	Yield/ plot (kg)	STAS yield at 14 % moisture (kg/ha)
1	—	18.2	67.0	1312	5942.50
2	acetamiprid (20 %)	18.7	67.7	1710	7697.84
3	imidacloprid (600 g/l)	18.2	68.3	2760	12501.00
4	cyantraniliprole (625 g/l)	18.9	67.3	1944	8729.70
5	lambda-cyhalothrin (4 g/kg)	18.6	66.1	1872	8437.48
6	lambda-cyhalothrin (50 g/l)	18.5	66.1	1674	7554.32

However, there weren't significant statistical differences between variants concerning weevils attack intensity ($p<0.5$). A possible reason for this situation is because of unfavorable weather conditions for weevils, registered in early vegetation stages of the maize crop. In previous study, in case of high attack of the maize leaf weevil, untreated variant was destroyed by the weevils (Georgescu et al., 2018). Also, variants with single foliar spray, without seed treatment can be destroyed (Georgescu et al., 2021a).

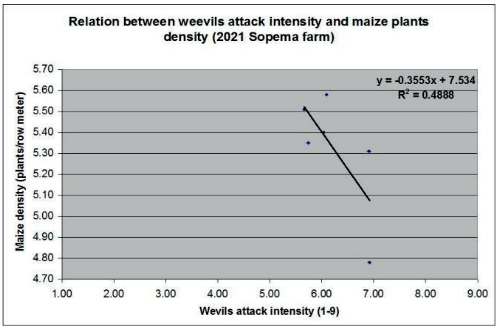

Figure 3. Relation between weevils attack intensity and maize plants density (2021 Sopema farm)

Data from table 4 reveal that in this trial, in conditions of the commercial farm, highest maize yield it has registered in case of maize seeds treated with imidacloprid active ingredient, followed by variant with seed treatment with cyantraniliprole active ingredient. Lowest maize yield was registered in case of control (untreated variant).

In this trial, it has registered a negative correlation between maize leaf weevil attack and maize plants density (Figure 3). Data from this experience it is in accordance with previous researches. Seed treatment with systemic insecticide, with rapid translocation of the active ingredient in plants, after maize emergence, is the highest effective method for controlling of maize leaf weevil attack, when maize plants are in early vegetation stages (Bărbulescu et al., 2001b; Popov et Bărbulescu, 2007; Georgescu et al., 2018, 2021a; Trotuș et al., 2019). Further studies are necessary, in different climatic conditions and pest pressure to evaluate cyantraniliprole active ingredient effectiveness in controlling of the *T. dilaticollis* attack at maize crop.

CONCLUSIONS

The attack of the maize leaf weevil (*Tanymecus dilaticollis* Gyll) at the maize plants, at the experimental site from Sopema farm (Mihail Kogalniceanu, Ialomița County), where it has made the assessments, was moderate, as a result of the unfavorable weather conditions from period when maize plants were in BBCH 10-BBCH 14 stage.

In the conditions of the year 2021, lowest weevils attack intensity it has registered in case of treated seeds variants.

In the conditions of the year 2021, from experimental location, it hasn't registered significant statistical differences between weevils attack at maize plants from variants with seeds treated and the rest of the variants from this experiment ($p<0.05$).

In conditions of the year 2021, from experimental location, it hasn't registered significant statistical differences between experimental variants, concerning maize plant density.

No phytotoxic effect occurred at maize plants after seed treatment, foliar or granules application of the insecticides.

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