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HOW EFFECTIVE IS FOLIAR TREATMENT FOR CONTROLLING THE MAIZE LEAF WEEVIL (*Tanymecus dilaticollis* Gyll) IN ROMANIA?

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Abstract

Maize leaf weevil (Tanymecus dilaticollis Gyll) is the main pest of the maize crops, mainly in south and south-east of the Romania. Each year, around one million hectares cultivated with maize is attacked by this pest, with different level of the attack intensities. This paper presents the results of researches concerning the effectiveness of the maize foliar treatment with acetamiprid active ingredient, for controlling of the maize leaf weevil, in absence of the seeds treatment with systemic insecticides. The experience were carried out in south-east of the Romania, in favorable area for T. dilaticollis, at NARDI Fundulea, ARDS Marculesti and ARDS Braila, in 2019 and 2020. In case of moderate weevils attack, registered in spring of 2019, the percentage of plants that escaping of the attack ranged from 76.25 to 86.36 % in case of untreated variant, while in case of treated variant, with acetamipird active ingredient, saved plants percent ranged from 77.73 % to 88.12 %. In spring of 2020, the weevils attack at maize plans was low at NARDI Fundulea and ARDS Marculesti, where percentage of the saved plants was higher then 90 %, and moderate at ARDS Braila, when saved plants percent was higher then 77 %. Results from the field trials show that foliar treatment with acetamiprid, don't provide effective protection of the maize plants, in first vegetation stages (BBCH 10-BBCH 14), against maize leaf weevil attack.

Key words: *maize, weevil, foliar treatment, control.*

INTRODUCTION

In last years, Romania has more than 2.4 million hectares cultivated with maize which represents the highest area within the EU27 (Eurostat, 2019; MADR data, 2021). Maize leaf weevil (*Tanymecus dilaticollis* Gyll) is the main pest of maize crops, mainly in south and south-east of the Romania (Paulian et al., 1972; Voinescu et al., 1985; Barbulescu et al., 1991, 2001a; Popov, 2002; Popov et al., 2004; Georgescu et al., 2014, 2018; Toader et al., 2020). Each year, around one million hectares cultivated with maize is attacked by this pest, with different level of the attack intensities (Barbulescu et al., 2001a; Popov, 2002, 2003; Popov et al., 2005, 2006a). The pest is dangerous when maize plants crops are in early vegetation stages, from the emergence until the four leaves stage (Popov et Barbulescu, 2007). After four leaves (BBCH 14) stage, weevils have feeding only with leaf margins and damages are less economically important (Rosca et Istrate, 2009). In some cases, weevils attack can occur before plants emergence above soil surface, causing high yield losses, sometimes compromising not only maize crops, but also sunflower and sugar beet (Barbulescu et al., 2001b). Data from the literature make in evidence that in south-east of the Romania, pest density ranged between 15 and 80 weevils/m^2 (Barbulescu, 1995, 1996, 1997, 2001; Popov et al., 2007a). In some extreme cases, it has reported a pest density of 160 weevils/m^2, in the Dobrogea area (Voinescu, 1987 cited by Rosca and Istrate, 2009). Researches made at NARDI Fundulea revealing that higher biological reserve of the maize leaf weevil (*T. dilaticollis*) it has registered in case of maize monoculture and sunflower cultivated after maize (Paulian, 1972; Barbulescu et Voinescu, 1998; Voinescu et Barbulescu, 1998). In some cases, even if the maize crop was sowed in plots with low pest reserve, the weevils can migrate from neighborhood plots that were sowed with maize in previous years (Barbulescu, 2001b; Popov et Barbuescu, 2007). As a result of both, the increasing area cultivated with maize and sunflower and decreasing number of economically effective crops, in favorable pest area from south and south-east of Romania, farmers couldn't make a proper rotation (Dachim, 2016; Lup et al., 2017). Maize leaf weevil is a thermo and xerophilous insect specie, being spreading especially in arid and semi-arid areas from Romania (Paulian, 1972). According to Popov et al. (2006b), weevils are very active at high air temperatures and low humidity, registered in the period when maize plants are in early vegetation stages during low air temperatures and high rainfall amount represent unfavorable conditions for pest activity at ground surface. Long term studies make evidence that climate changes will increase the prevalence of insect pests in maize agroecosystems from Central and South-East of Europe, including Romania Diffenbaugh et al., 2008; Olesen, et al., 2011; Bebber et al., 2014; Choudhary et al., 2019). Researches from Romania effectuated in last decades, at I.C.C.P.T. Fundulea (actual N.A.R.D.I. Fundulea), demonstrate that the highest effective method for controlling the maize leaf weevil attack, when maize plants are in early vegetation stages (BBCH 10-BBCH 14) is seeds treatment with systemic insecticides with a high solubility degree and rapid translocation of the active ingredient to the young plants (Voinescu, 1985; Barbulescu et al., 1993, 1994, 1995; 2001b; Popov, 2002, 2003; Popov et al., 2006b, 2007b; Popov et Barbulescu, 2007; Vasilescu, 2005; Georgescu et al., 2014, 2018; Trotus et al., 2018). After European Commission Regulations 218/783, 218/784, and 218/785, the use of imidacloprid, clothianidin and thiamethoxam active ingredients for all field crops, both like seeds treatment and foliar application will be totally banned in UE, from 2019 (Official Journal of the European Union, 2018a,b,c). As result no insecticides will remain available for sunflower seed treatment against *T. dilaticollis* in Romania. According Ionel (2014), lack of the seeds treatment alternatives for spring crops, including maize, can have negative impact in Romanian agriculture in following years. Kathage (2018) mentioned that after ban of seeds treatment with neonicotinoids of the maize, sunflower and oilseed rape in EU, farmers use foliar and soil treatments that are more expensive comparative with seeds treatment. In this paper, it has presented some results of the researches concerning the effectiveness of the foliar treatment of the maize crops with the acetamiprid active ingredient, in three locations from south-east of Romania for controlling the maize leaf weevil (*T. dilaticollis*), in the absence of the seed treatment with systemic insecticides.

MATERIALS AND METHODS

The field trials were carried out between 2019 and 2020, at the experimental field of the Plants and Environment Collective, from National Agricultural Research Development Institute (NARDI), Fundulea, Calarasi County (lat. N: 44.46; long. E: 26.32; altitude: 68 m), experimental field of Agricultural Research Development Station (ARDS) Marculesti (lat. N: 44.25, long. E: 27.30, alt. 39.30 m), Calarasi County and experimental field of the Agricultural Research Development Station (ARDS), Braila (lat. N: 45.12, long. E: 27.55, alt. 14.52 m), Braila County. These three locations are placed in the favorable area of *T. dilaticollis* in south-east of the Romania.

Table 1. Active ingredients used in this research

Variant no.	**Active ingredient** (concentration)	**Rate** (kg. c. p./ha)*
1	control (untreated)	—
2	acetamiprid (20 %)	0.1

*kilogram commercial product per hectare

The active ingredient used in this study was acetamiprid (20 %), a wide broad-spectrum insecticide authorized for foliar treatment of the maize crops in Romania (table 1). Experimental plots were arranged according to the randomized blocks scheme. Each plot has 10 m in length, and 4.2 m wide as a result plot area was 42 m^2. For this experience, it has used F423 maize hybrid (FAO 420). Distance between rows was 0.7 m.

For this experience it has used lower plants density. On each plot it has sowed 180 maize seeds, that correspond on a density of 42857 seeds/ha. The purpose for using of lower plants density in this experience is to assure better conditions for weevils attack. The field trial was carried out in the plots cropped previous years with maize, thus favoring a high pest biological reserve. To avoid migration of the weevils from one plot to another, the plots were laterally isolated with a 2 m wide strip sowed with pea, a plant repellent for this insect (Paulian, 1972).

- In 2019, at NARDI Fundulea, maize plants were sowed on 12 May, full plants emergence was recorded on 20 May while BBCH 14 stage was recorded on 27 May;
- In 2019, at ARDS Marculesti, maize plants were sowed on 22 April, full plants emergence was recorded on 4 May while BBCH 14 stage was recorded on 14 May;
- In 2019, at ARDS Braila, maize plants were sowed on 4 May, full plants emergence was recorded on 16 May while BBCH 14 stage was recorded on 26 May;
- In 2020, at NARDI Fundulea, maize plants were sowed on 15 April, full plants emergence was recorded on 26 April while BBCH 14 stage was recorded on 8 May;
- In 2020, at ARDS Marculesti, maize plants were sowed on 24 April, full plants emergence was recorded on 4 May while BBCH 14 stage was recorded on 14 May;
- In 2020, at ARDS Braila, maize plants were sowed on 19 May, full plants emergence was recorded on 2 June while BBCH 14 stage was recorded on 13 June.

Foliar treatment with acetamiprid active ingredient was applied, after plants emergence, when maize plants were in BBCH 11-12 stages. Evaluation of the effectiveness of the foliar treatment for controlling the maize leaf weevil was made after a methodology elaborated at NARDI Fundulea, by Paulian (1972) and improved by Bărbulescu (1995, 2001b).

Attack intensity of weevils was assessed when sunflower plants arrive in four leaves stage (BBCH 14). At each plot it has marked 20 plants, from four central rows (5 plant/row). Before assessment, the plants were marked with sticks, in stair system. Weevils attack was rated on a scale from 1 to 9, 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.

Saved plant percent was rated at 30 days from sunflower emergence, by counting all the emerged plants from a plot and comparing them with the number of sowed sunflower seeds/plot.

Meteorological data were collected from automatic weather stations, placed in the field site from the three locations were it was carried out this study. It has registered average air temperature and daily rainfalls amount.

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

Temperatures and rainfalls from the spring period influenced weevils activity on the ground, such as the feeding process and mating. During this field trial, in three locations from the south-east of Romania it has monitoring weather conditions. Rosca et Istrate (2009) mentioned that the maize leaf weevil is very active when the temperature recorded on the ground level is higher than 18 °C and daily air temperature is higher than 20 °C. Popov et al. (2006b) refer to high weevils activity in case of lack of rainfalls. The same authors concluded that if weather conditions from the early stages of the maize (BBCH 10-BBCH 14) are favorable for weevils activity, then attack intensity of this pest at maize plants can be higher. Analyzing the daily temperatures and rainfalls, recorded between maize plants emergence and four leaves stage, it has ascertained that in 2019, at NARDI Fundulea, the maximum temperature was higher than 20 °C on all days (Figure 1). Rains occurred 24 hours after the emergence and at 4 days from the emergence favored plants development, as a result, the weevils attack intensity was moderate. In the spring of 2020, at NARDI Fundulea, plants emergence was recorded on 26 April. In the first four days after plants' emergence, maximum air temperatures were higher than 20 °C. However, it has recorded high-temperature differences between minimum and maximum air temperature (higher than 20 °C on 29 April) in the same interval.

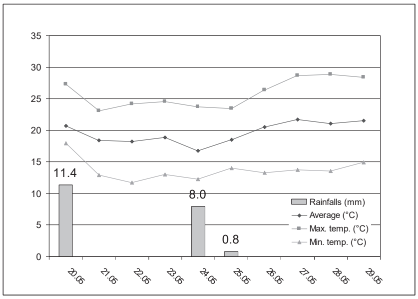

Figure 1. Daily temperatures and rainfalls recorded between maize plants emergence and four leaves stage in the spring of the year 2019 at NARDI Fundulea

Between 3 and 6 May it has recorded 30.8 mm of rains while temperatures decreasing (Figure 2). As result of the high differences between minimum and maximum air temperature recorded in first 96 hours after the plants emergence, the weevils activity of the ground was low. Decreasing of the air temperature after 30 April and high rainfalls amount recorded in next days favored maize plants growing and development and represent unfavorable conditions for pest activity.

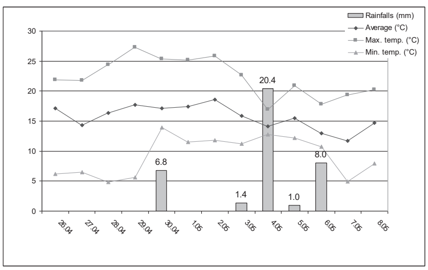

Figure 2. Daily temperatures and rainfalls recorded between maize plants emergence and four leaves stage in the spring of the year 2020 at NARDI Fundulea

As a result, because of unfavorable weather conditions recorded in early vegetation stages of the maize plants, the weevils the attack was lower than the previous year. The situation was quite similar at ARDS Marculesti experimental site. In the spring of 2019, weather conditions recorded between maize emergence and four leaves stage was less favorable for weevils activity on the ground. After 48 hours from the emergence, it has recorded 18.2 mm of rains and air temperatures decreasing below 15 °C (Figure 3).

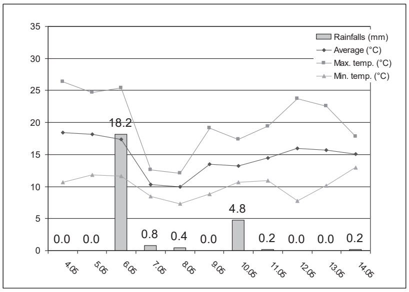

Figure 3. Daily temperatures and rainfalls recorded between maize plants emergence and four leaves stage in the spring of the year 2019 at ARDS Marculesti

In the next five days, air temperatures were lower then 20 °C, as results weevils activity was lower and maize plants escape of the attack. The situation was quite similar in the spring of 2020. At 24 hours after the plant's emergence, it has recorded 15.8 mm of rains and maximum air temperature decreasing below 15 °C (Figure 4).

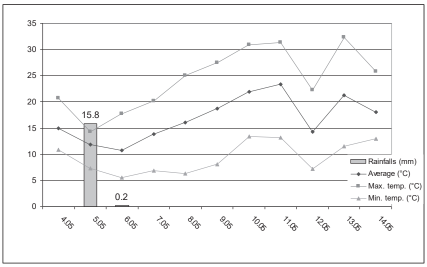

Figure 4. Daily temperatures and rainfalls recorded between maize plants emergence and four leaves stage in the spring of the year 2020 at ARDS Marculesti

Even if the temperatures increasing gradually in next days, as a result of the high rainfalls, amount recorded at 24 hours after emergence maize plants have a normal growing and development in first days after the emergence, as a result, weevils attack intensity was lower, and most of the plants escape the attack.

Weather conditions recorded at ARDS Braila in the spring of 2019, between maize emergence and four leaves stage, were favorable for the weevils attack. The maximum air temperature was higher than 20 °C in all days between plants emergence and four leaves stage (Figure 5). However, due to the rains on 24 and 25 May, maize plants have rapid growth, and the weevil attack intensity was moderate.

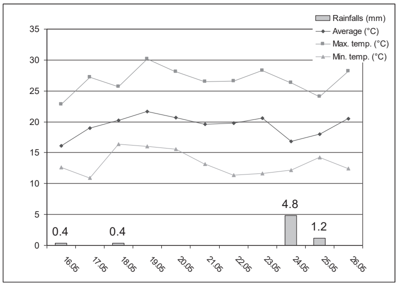

Figure 5. Daily temperatures and rainfalls recorded between maize plants emergence and four leaves stage in the spring of the year 2019 at ARDS Braila

In 2020, at ARDS Braila, maize plants were sowed on 19 May. However, as a result of the drought, plants emergence occurred on 2 June. Weather conditions recorded between maize emergence and the four leaves stage were favorable for weevils activity on the ground (Figure 6). However, the pest attack was moderate because plant emergence occurred in June. Paulian (1972) mentioned that the highest weevils attack occurred in plants that emerged in the last 10 days of April and the first 10 days of May.

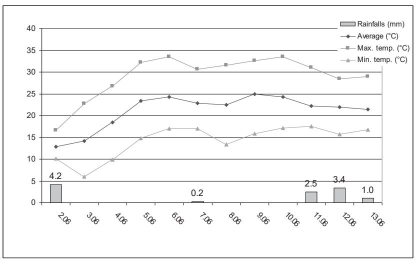

Figure 6. Daily temperatures and rainfalls recorded between maize plants emergence and four leaves stage in the spring of the year 2020 at ARDS Braila

Recent researches made at NARDI Fundulea make in evidence that there weren't high statistical differences on weevils attack at maize plants sowed in April and May (Georgescu et al., 2019).

In this field trial, in spring of 2019, the attack intensity of the maize leaf weevils (*T. dilaticollis*) at maize untreated plants, on a scale from 1 to 9, was moderate at NARDI Fundulea and ARDS Braila (5.24 and 5.25) and lower at ARDS Marculesti (Table 2).

Table 2. Attack intensity of *T. dilaticollis* at maize plants, in field conditions, (2019)

Active ingredient (concentration)	**Rate** (kg. c. p./ha)	**Attack intensity (1-9)**		
		1*	**2***	**3***
control (untreated)	—	**5.24a**	**4.00a**	**5.25a**
acetamiprid (20 %)	0.1	**4.80a**	**3.81a**	**4.73a**
LSD P=0.05		1.214	0.982	0.568
Standard deviation (SD)		0.540	0.436	0.252
Variation coefficient (C.V.)		10.750	11.170	5.060
Replicate F		0.107	0.729	0.346
Replicate Prob(F)		0.9505	0.5996	0.7965
Treatment F		1.315	0.369	8.646
Treatment Prob(F)		0.3347	0.5862	0.0605

*1-NARDI Fundulea; 2-ARDS Marculesti; 3-ARDS Braila

**Means followed by same letter or symbol do not significantly differ (p<0.05, Student-Newman-Keuls test)

At the same time, attack of the weevils at maize plants treated with acetamiprid active ingredient was slightly lower compared with untreated variants in all three locations. However, in all three locations there weren't recorded significant statistical differences between weevils attack at treated plants and attack at untreated plants (p<0.05).

Table 3. Influence of the foliar treatment, concerning saved plats percent, at 30 days from maize emergence (2019)

Active ingredient (concentration)	**Rate** (kg. c. p./ha)	**Saved plants percent (%)**		
		1*	**2***	**3***
control (untreated)	—	**76.25a**	**86.38a**	**82.67a**
acetamiprid (20 %)	0.1	**77.73a**	**88.12a**	**83.60a**
LSD P=0.05		6.431	11.961	4.235
Standard deviation (SD)		2.858	5.316	1.882
Variation coefficient (C.V.)		3.710	6.090	2.260
Replicate F		2.215	1.038	2.727
Replicate Prob(F)		0.2653	0.4881	0.2160
Treatment F		0.539	0.219	0.493
Treatment Prob(F)		0.5160	0.6719	0.5332

*1-NARDI Fundulea; 2-ARDS Marculesti; 3-ARDS Braila

**Means followed by same letter or symbol do not significantly differ (p<0.05, Student-Newman-Keuls test)

Concerning saved plants percent, data from table 3 reveal that in spring of 2019, at three experimental locations, in the case of foliar application with the acetamiprid active ingredient, when maize plants were in BBCH

12-13 stage, the percentage of plants that escape of weevil attack was slightly higher in case of treated variant. However, there weren't recorded significant statistical differences compared with untreated variant ($p<0.05$).

In conditions of the lower weevils attack, recorded at NARDI Fundulea and ARDS Marculesti, in spring of 2020, there weren't recorded significant statistical differences between treated and untreated variant ($p<0.05$). The weevils attack was higher at ARDS Braila, compared with the other two locations. However, even if the attack was lower at plants treated with acetamiprid active ingredient compared with untreated plants, there weren't recorded significant statistical differences between the two variants (Table 4).

Table 4. Attack intensity of *T. dilaticollis* at maize plants, in field conditions, (2020)

Active ingredient (concentration)	**Rate** (kg. c. p./ha)	**Attack intensity (1-9)**		
		1*	**2***	**3***
control (untreated)	—	**3.86a**	**3.66a**	**5.38a**
acetamiprid (20 %)	0.1	**3.66a**	**3.47a**	**4.94a**
LSD P=0.05		0.231	0.682	1.336
Standard deviation (SD)		0.103	0.303	0.594
Variation coefficient (C.V.)		2.730	8.500	11.520
Replicate F		7.039	1.031	0.046
Replicate Prob(F)		0.0716	0.4903	0.9847
Treatment F		7.775	0.850	1.099
Treatment Prob(F)		0.0685	0.4246	0.3715

*1-NARDI Fundulea; 2-ARDS Marculesti; 3-ARDS Braila
**Means followed by same letter or symbol do not significantly differ ($p<0.05$, Student-Newman-Keuls test)

As a result of the low weevils attack at the maize plants recorded in the spring of 2020 at NARDI Fundulea and ARDS Marculest, the saved plant percent was higher than 90 $ (Table 5). Contrarily, due to the higher pest attack, the percentage of that maize plant that escapes the attack was below 80 % at ARDS Braila. In all situations that occurred during this two-years field study, in three locations, there weren't recorded significant statistical differences in case of saved plants percent at treated variant compared with control (untreated) variant ($p<0.05$). Foliar spray with the acetamiprid active ingredient, in the absence of the seeds treatment, didn't provide proper protection of the maize plants in early vegetation stages against maize leaf weevil attack. Similar results were obtained in studies effectuated in the conditions of a commercial farm in case of high pest pressure (Georgescu et al., 2018, 2020).

Table 5. Influence of the foliar treatment, concerning saved plats percent, at 30 days from maize emergence (2020)

Active ingredient (concentration)	**Rate** (kg. c. p./ha)	**Saved plants percent (%)**		
		1*	**2***	**3***
control (untreated)	—	**90.59a**	**92.94a**	**77.54a**
acetamiprid (20 %)	0.1	**91.86a**	**93.67a**	**79.06a**
LSD P=0.05		8.999	5.374	2.719
Standard deviation (SD)		4.000	2.389	1.208
Variation coefficient (C.V.)		4.390	2.560	1.540
Replicate F		2.060	1.907	12.871
Replicate Prob(F)		0.2840	0.3046	0.0321
Treatment F		0.220	0.189	3.189
Treatment Prob(F)		0.6709	0.6928	0.1721

*1-NARDI Fundulea; 2-ARDS Marculesti; 3-ARDS Braila
**Means followed by same letter or symbol do not significantly differ ($p<0.05$, Student-Newman-Keuls test)

CONCLUSIONS

In the climatic conditions from the south-east of Romania, at the experimental field from NARDI Fudulea and ARDS Marculesti, *T. dilaticollis* attack at maize plants, in early vegetation stages (BBCH 10-BBCH14) was moderate in the spring of the year 2019 and lower in the spring of the year 2020. At ARDS Braila, weevils attack was moderate in both years of this field study.
In conditions of both moderate and lower attack recorded in three locations from this field trial, in spring of 2019 and 2020, foliar spray with the acetamiprid active ingredient, in the absence of seed treatment, don't provide effective protection of the maize plants, in first vegetation stages (BBCH 10-BBCH 14), against maize leaf weevil attack.

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