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Original Article

Influence of Soil Works on the Damage by the Western Corn Rootworm (*Diabrotica Virgifera Virgifera* Leconte) in Grain Maize in the Banat's Plain

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Abstract

Because of the damage caused currently by the Western corn rootworm (*Diabrotica virgifera virgifera* LeConte), we need to pay particular attention to all its control methods. In this respect, soil works, together with crop rotation, play an important role. In the field, the mean values of damage on maize roots on different lands differentiated from the point of view of soil works had a lower span (0.06). Ploughing caused a span of 0.51 associated with a mean variability (15.47%), i.e. a significantly higher attack in 2010 than in 2011 and 2012. The damage on the grubbered lands showed values ranging between 1.69 in 2011 and 2.13 in 2010, with a span of 0.44 and a variability of 14.36%. In disked land, there were damage values between 1.67 in 2011 and 2.09 in 2010 on the background of lower variability (11.96%) than on previous lands. In the field, under an isolator, there were no significant differences in maize root damage. Thus, on the land ploughed, in the conditions of 2012, the attack was 15-27% significantly lower than in 2011 and 2010. In the disked variant, maize root damage reached a span of 0.97, inferior to the other two lands, with limits between 1.67 in 2012 and 2.64 in 2010. The level of the attack on the grubbered land had a span of 1.13, with limits between 1.63 in 2012 and 2.76 in 2010.

Keywords: *Diabrotica virgifera virgifera* LeConte, grain maize, ploughing, disking, grubbering, isolator, damage, span, variability.

1. Introduction

Western corn rootworm (*Diabrotica virgifera virgifera* LeConte) is native from Northern and Central America (Mexico, Costa Rica, Nicaragua and Guatemala). LeConte first described the insect in 1865, in western Kansas. At present, it lives on the American continent, in Canada and in Europe, and is an important pest in maize.

In Romania, *Diabrotica virgifera virgifera* LeConte was first seen on July 5, 1996, in Nădlac, Arad County, when three adults were captured on an adhesive yellow trap. Lately, the pest spread at a quick pace towards northeast and south, covering important areas in the Banat-Crisana Plain, in the Transylvanian Plain and Plateau, in Oltenia and Partially in Wallachia, where it is common in maize [5, 6, 8].

Diabrotica virgifera virgifera LeConte develops important populations and causes important damage on vast areas cultivated with maize in monoculture. In such conditions, the insect

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has enough quality food sources and keeps infesting the crop, multiplying easily the biological reserve. Where maize is cultivated in crop rotation with other crops, the pest population may be suppressed and the damage is minimum [10].

The integrated control system supposes harmonious use of cultivation technologies, biological measures, selective chemical measures and natural biotic control factors to keep the pest populations below economic damage threshold. Integrating technological measures as plant protectors needs adapting to the requirements of the phyto-sanitary factor correlated with the requirements of controlling the target pest *Diabrotica virgifera virgifera* LeConte, aiming at controlling other important pests as well such as *Tanymecus dillaticollis* Gyll.; *Agriotes spp.*, or *Ostrinia nubilalis* Hb. [7].

Choosing the cultivation technology aims at developing the conditions necessary for the growth and development of the crop, i.e. reducing pest growth, multiplication and spread conditions. This is where soil works become extremely important.

Soil work systems have evolved conceptually and from the perspective of agricultural equipment in the last decades. Sustainable agriculture focuses increasingly on soil conservation systems with different technical variants. At present, soil works should be taken into account in direct correlation with crop rotation [3, 1, 9, 2].

2. Material and Method

Research was carried out over three years (2010-2012) on the private lands of the company SC Popa Ovidiu SRL Grabaţ, Timiş County, Romania. The experiments were carried out in a stationary field, in two neighbouring localities on a typical chernozem proxicalcaric, medium clay/clay medium, on medium-fine carbonatic loess. The experimental fields were established in a field naturally populated by *Diabrotica virgifera virgifera* LeConte: the Grabaţ area has been a damage area ever since the appearance of the pest in Romania from ex-Yugoslavia.

The experiments were monofactorial with randomised blocks in four replicates.

The experimental factor – soil work system – had three graduations with the following experimental variants: V_1 – ploughing in the fall 25-30 cm deep with furrow reversal; V_2 – grubbering in the fall 25-30 cm deep with soil aeration; V_3 – disking in the spring 15-20 cm deep.

Soil basic work was supplemented by germination bed preparation in spring consisting in two passages of the disk harrow about 15 cm deep, applied indifferentiately. Experimental plots measured 500 m^2 each. Experiments were set on a land naturally populated by *Diabrotica virgifera virgifera* LeConte, i.e. on a land cultivated with maize in the previous year and on which phyto-sanitary controls identified the considerable presence of a phyto-phage insect and the attack on the crop.

We made periodical measurements, polls and collection of biological material focusing on the insect and on the plant attacked. The samples were examined in the laboratory and evaluated numerically. The attack by the larvae was expressed through damage level using the IOWA grading scale. Data were processed and interpreted statistically. Evaluating the soil work system as a factor of influence in the agro-ecosystem was done by comparing the variants and by taking for control variant the classical soil work (ploughing with furrow reversal). In the experimental field, we evaluated the attack of the larvae on the maize roots in each experimental plot.

To evaluate the attack of the larvae on the maize roots, we analysed the plants under the isolator in samples of 4-5 plants/isolator and plants in the field, sampling 5 times five plants from each plot. Evaluating the attack was done at the end of the vegetation period, post harvesting, by examining the maize root system of the plants after washing.

We evaluated the maize root damage as intensity of the attack. To express the value of the attack, we used the IOWA grading scale with grades from 1 to 6: grade 1 – no attack; grade 2 – apparent damage, chewed maize roots; grade 3 – several maize roots are chewed along 3-4 mm; grade 4 – a maize root node (usually the second or third is entirely destroyed and keeps traces of fine maize roots); grade 5 – two nodes destroyed; grade 6 – three or several maize root nodes are destroyed.

Analysis data were processed statistically and we determined the mean, standard deviation of the mean and the variability coefficient. The significance of the differences was represented both with symbols (*; **;***; ^{0}; ^{00}; ^{000}) and letters: we considered significant the differences between variants graded with different letters [4]. Data processing was done using computer software.

3. Results and Discussions

Influence of soil works on maize root damage in the field during 2010-2012. Variance analysis shows that the climate factors of the experimental years had a real strong influence statistically ensured on the maize root damage by *Diabrotica virgifera virgifera* LeConte. Soil works

had little, insignificant influences on this feature. The combined effect of experimental years and soil works has significantly influenced the damage level of maize roots by *Diabrotica virgifera virgifera* LeConte. There were significant differences between replicates at experimental level (Table 1).

Table 1. Variance analysis regarding the effect of year and soil work on maize root damage caused by *Diabrotica virgifera virgifera* LeConte

Variation source	SP	GL	S^2	F test
Total	4.490	71		
Replicates	0.548	7	0.078	F= 2.47*
Years	2.980	2	1.490	F= 46.98**
Year error	0.444	14	0.032	
Soil works	0.044	2	0.022	F= 2.44
Years x Soil works	0.095	4	0.024	F= 2.63*
Soil works error	0.379	42	0.009	

Taking into account the unilateral effect of climate conditions during the experimental period, the damage level had a span of 0.45 with values between 1.65 in 2011 and 2.10 in 2010, on the background of medium variability (13.74%), (Table 2).

Table 2. Effect of experimental year on maize root damage level caused by *Diabrotica virgifera virgifera* LeConte

Year	Means		Relative values (%)	Difference/significance
2011-2010	1.65	2.10	78.57	-0.45^{000}
2012-2010	1.69	2.10	80.48	-0.41^{000}
2012-2011	1.69	1.65	102.42	0.04

$DL_{5\%} = 0.11$; $DL_{1\%} = 0.15$; $DL_{0.1\%} = 0.21$

As for the differences between experimental years, we see that in the climate conditions of 2010 the attack on the maize roots was very significantly superior to that of 2011 and 2012.

Likewise, in the conditions of 2011 and 2012, there were no significant differences from the point of view of the maize root damage level at experiment level. Mean values of the maize root damage level on the lands differentiated by soil works had a smaller span (0.6) with limits between 1.78 in ploughing to 1.84 in grubbering, on the background of very low variability (1.68%). Taking into account this variability and the small differences between the three soil works, we see that soil works had a little influence on maize root damage level according to the results of variance analysis (Table 3).

Table 3. Effect of soil preparation on maize root damage level caused by *Diabrotica virgifera virgifera* LeConte

Soil works	Means		Relative values (%)	Difference/significance
Grubber-Plough	1.84	1.78	103.37	0.06*
Disk-Plough	1.82	1.78	102.25	0.04
Disk-Grubber	1.82	1.84	98.91	-0.02

$DL_{5\%} = 0.06$; $DL_{1\%} = 0.07$; $DL_{0.1\%} = 0.10$

Table 4. Effect of year and soil work on maize root damage level caused by *Diabrotica virgifera virgifera* LeConte

Year	Soil works			$\bar{x} \pm s_{\bar{x}}$	$S_{\%}$
	Plough	Grubber	Disk		
2010	x 2.10a	x2.13a	x2.09a	2.10±0.04	10.03
2011	y1.59b	x1.69b	xy1.67b	1.65±0.02	5.84
2012	x1.66b	x1.70b	x1.71b	1.69±0.02	5.53
$\bar{x} \pm s_{\bar{x}}$	1.78±0.06	1.84±0.05	1.82±0.04	1.81±0.03	
$S_{\%}$	15.47	14.36	11.96	13.85	

Years $DL_{5\%} = 0.13$; $DL_{1\%} = 0.18$; $DL_{0.1\%} = 0.23$
Soil works $DL_{5\%} = 0.10$; $DL_{1\%} = 0.13$; $DL_{0.1\%} = 0.17$

Are considered significant the differences between combinations graded with different letters: a,b,c – for vertical comparisons; x,y,z – for horizontal comparisons. Taking into account the effect of different climate conditions on maize root damage on the land ploughed we see a span of 0.51 associated with a mean variability (15.47%): there was a significantly higher attack in 2011 than in 2012.

The damage level on the lands grubbered had values between 1.69 in 2011 and 2.13 in 2010, with a span of 0.44 and a variability of 14.36%. Thus, in 2010, on these lands there were maize root damage levels significantly superior to those of 2011 and 2012.

On the lands disked, there were values of the maize root damage level between 1.67 in 2011 and 2.09 in 2010, on the background of lower variability (11.96%) compared to the previous lands. On this land we also see that in the conditions of 2010 there were maize root damage levels significantly superior to those of the other two experimental years (Table 4).

As for the effect of different soil works on maize root damage level in the three years, in general there were no real significant differences except for 2011, when ploughing caused a significant decrease of the attack compared to grubbering.

Influence of soil works on maize root damage under the isolator during 2010-2012. Under the isolator, the climate conditions of the experimental period had a very distinctly significant influence on maize root damage level. Soil works had a very low influence, not ensured statistically on the attack.

The combined effect of climate conditions during the studied period and of soil works had a considerable influence ensured statistically on the attack by *Diabrotica virgifera virgifera* LeConte. Results were significantly influenced by the variability of the replicates (Table 5).

Table 5. Variance analysis of the effect of year and soil works on maize root damage level under the isolator caused by *Diabrotica virgifera virgifera* LeConte

Variation source	SP	GL	S^2	F test
Total	16.995	71		
Replicates	0.564	7	0.081	F = 2.35*
Years	12.716	2	6.358	F = 194.19**
Year error	0.48	14	0.034	
Soil works	0.001	2	0.001	F = 0.01
Years x Soil works	0.723	4	0.181	F = 3.02*
Soil work error	2.511	42	0.060	

As for the effect of climate conditions on maize root damage under the isolator (Table 6), there is a span of 1.03 on the background of associated variability of 10.62%. The conditions of 2010 were significantly more favourable to maize root attack compared to the other two years, with an increase of maize root damage level of 34-61%.

In 2012, there was also a maize root damage level 20% significantly higher than in 2011.

Table 6. Effect of experimental year on maize root damage level under the isolator caused by *Diabrotica virgifera virgifera* LeConte

Year	Means		Relative values (%)	Difference/significance
2011-2010	2.01	2.70	74.44	-0.69^{000}
2012-2010	1.67	2.70	61.85	-1.03^{000}
2012-2011	1.67	2.01	83.08	-0.34^{000}

$DL_{5\%} = 0.11$; $DL_{1\%} = 0.16$; $DL_{0.1\%} = 0.22$

At experimental level there were no significant differences in maize root damage level under the isolator: the values were close and the variation span was extremely low (Table 7).

Table 7. Effect of soil preparation on maize root damage level in under the isolator caused by *Diabrotica virgifera virgifera* LeConte

Soil works	Means		Relative values (%)	Difference/significance
Grubber-Plough	2.12	2.13	99.53	-0.01
Disk-Plough	2.13	2.13	100.00	0.00
Disk-Grubber	2.13	2.12	100.47	0.01

$DL_{5\%}$=0.14; $DL_{1\%}$=0.19; $DL_{0.1\%}$=0.25

On the background of different climate conditions during the experimental period (Table 8), maize root damage level under the isolator had a high variability ranging between 20.60% on the disked land and 24.63% on the ploughed land. Thus, on the land ploughed in the conditions of 2012 there was maize root attack 15-27% significantly lower than in the conditions of 2011 and 2010. Climate conditions in 2010 were significantly more favourable for the attack by *Diabrotica virgifera virgifera* LeConte, with an increase of about 35% of the maize root damage under the isolator. The maize root attack level on the grubbered land had a span of 1.13, with limits between 1.63 in 2012 and 2.76 in 2010.

Likewise, on this land, climate conditions had a major influence ensured statistically on the attack on the maize roots.

On the land disked, the maize root damage level had a span of 0.97, inferior to the other two lands, with limits between 1.67 in 2012 and 2.64 in 2010. On this land also the maize root attack level was significantly higher in 2010, with increases of 27-58% compared to 2011 and 2012 (Table 8.).

Table 8. Effect of year and soil preparation on maize root damage level under the isolator caused by *Diabrotica virgifera virgifera* LeConte

Year	Soil works			$\bar{x} \pm s_{\bar{x}}$	$S_{\%}$
	Plough	Grubber	Disk		
2010	x2.69a	x2.76a	x2.64a	2.13±0.11	6.57
2011	x1.99b	x1.96b	x2.07b	2.12±0.11	16.08
2012	x1.70c	x1.63c	x1.67c	2.13±0.09	9.34
$\bar{x} \pm s_{\bar{x}}$	2.70±0.04	2.01±0.06	1.67±0.03	2.12±0.06	
$S_{\%}$	24.63	24.61	20.60	23.02	

Years $DL_{5\%} = 0.23$; $DL_{1\%} = 0.30$; $DL_{0.1\%} = 0.39$

Soil works $DL_{5\%} = 0.25$; $DL_{1\%} = 0.33$; $DL_{0.1\%} = 0.43$

Are considered significant the differences between combinations graded with different letters: a, b, c – for vertical comparisons; x, y, z – for horizontal comparisons. No matter the climate conditions during the experimental period, there were no significant differences between soil works from the point of view of their effect on maize root damage under the isolator.

The variation span and variability were lower in 201 and higher in 2011.

4. Conclusions

Research carried out during 2010-2012 regarding the influence of soil work on maize root damage caused by the Western corn rootworm (*Diabrotica virgifera virgifera LeConte*) has led us to the following conclusions:

No matter the climate conditions during the experimental period, there were no significant differences between soil works from the point of view of their effect on maize root damage level. The variation span and variability were lower in 2010 and higher in 2011.

Mean values of the maize root damage level in the field on different lands from the perspective of soil works had a low span of 0.06 with limits between 1.78 on ploughed land and 1.84 on grubbered land on the background of very low variability (1.68%).

Taking into account the effect of different climate conditions on maize root damage on the ploughed land, there was a span of 0.51 associated with a medium variability (15.47%): in 2010, there was a significantly higher level of the attack than in 2011 and 2012.

The damage level on the grubbered land had values between 1.69 in 2011 and 2.13 in 2010, with a span of 0.44 and a variability of 14.36%. In the variant disked there were values of damage level between 1.67 in 2011 and 2.09 in 2010, on the background of lower variability (11.96%) compared to the previous lands.

Under the isolator, there were no significant differences between soil works from the point of view of maize root damage level, with close values and extremely low variation span. Depending on climate conditions in the experimental period, maize root damage level under the isolator had high variability between 20.60% on the disked land and 24.63% on the ploughed land.

On the disked land, maize root damage level had a span of 0.97, inferior to the other two lands, with limits between 1.67 in 2012 and 2.64 in 2010. On this land also the attack level was significantly higher in 2010, with increases of 27-58% compared to 2011 and 2012. The attack level on the grubbered land had a span of 1.13, with limits between 1.63 in 2012 and 2.76 in 2010.

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