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Review article

MONITORING THE BIOLOGY OF THE CORN ROOTWORM (*DIABROTICA VIRGIFERA*) FOR THE REGION OF KORÇA

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ABSTRACT

In recent years, the Korça region has planted an average of 6700 - 7000 ha of corn for grain. The most widespread cultivars for planting are mainly medium cycle, while long cycle is mainly planted Pioneer 630 Fao variety. During 2021, the corn rootworm *Diabrotica virgifera virgifera LeConte*, appeared sporadically. In 2022, this pest affected about 4,000 ha of corn, mainly in the flat area, and the highest rate of infection appeared in the Maliqi field. The pest was not present in the Korça region. Climate change, where mild winters leave the place to hot summers, favors the emergence of many pathogens and pests that were not previously present in this region. This pest has been detected and monitored in the flat area of our country since 1999 using the sex pheromone 8 – methyl – decane – 2 – oylpropanate. Until now, there has been no real study of *Diabrotica virgifera* for the Korça region. The insect mainly damages the root system of the corn, but also the female flower of the corn and the leaves, causing significant damage to the production. This is the first monitoring of *Diabrotica virgifera*, in the district of Korça.

Keywords: Diabrotica virgifera, corn, the female flower, monitoring, cultivar, damage.

INTRODUCTION

Diabrotica virgifera is a pest that originates from North America (Metcalf, R.L). According to EPPO Reporting Service no. 01 – 1996, Western corn rootworm (WCR) was first recorded in Europe near Surcin International Airport in Serbia in 1992. *Diabrotica virgifera virgifera* has spread almost throughout Europe. (Renata. B et al.,2021). In 1998 it was trapped near Venice airport in Italy and an eradication program is being carried out in this region. Again in 2000, *Diabrotica virgifera* was caught at 2 new airports in Italy and Switzerland. In 2001 the infection covered a fairly large area in Ticino, Lombardy and Piedmont. A new outbreak was discovered in 2002 near the Aviano military airport in Friuli – Venezia - Giulia. In 2002, *Diabrotica virgifera* was also found for the first time in France near Roissy, Le Bourget and Orly airports. (Renata. B et al.,2021).

In 2003, new outbreaks were reported in France, Belgium, the Netherlands, and the United Kingdom, again near international airports. (Renata. B et al.,2021). In 2004, the pest continued to spread in most areas where it was present. No new sites were reported to be infected in 2004. In 2005, *Diabrotica virgifera* was caught for the first time in Poland, and a few specimens were again trapped in the Netherlands near Schipol Airport. In 2007, *Diabrotica virgifera* was first

detected in Germany and eradication measures were taken. In 2009, *Diabrotica virgifera* was caught for the first time in Belarus, near the borders with Poland and Ukraine, as well as in northern Greece. (EPPO region, 2012). Economic damage was seen only in maize in Serbia and in some border areas in Croatia, Hungary, Romania and some areas in Bosnia-Herzegovina and Bulgaria. (Renata. B et al.,2021).

In our country, this pest has been monitored since 1999. It is widespread throughout the flat areas of our country and continues to be a serious pest of the corn crop. In the twentieth century, *Diabrotica virgifera* became a major corn pest in North America as corn planted surface increased. The practice of continuously growing areas with maize and not crop rotation was the reason for the expansion of the range of *Diabrotica virgifera*.
The insect became invasive and spread rapidly throughout Central Europe in 1992 and early in 2000. Although larvae move relatively short distances, imago flies in cornfields and can actively migrate several kilometers per year. Its adaptability to different climatic conditions is also reflected by its wide distribution area from Northern Mexico, across the USA, and into Canada. (Krysan and Miller, 1986). Both adults and larvae feed on the corn plant, but root feeding by larvae is the main cause of damage by reducing nutrient uptake from plant.

Root damage weakens plants and makes them more susceptible to wet or windy conditions. Adults feed on corn pollen, female flowers, and leaves, but may feed on a wide range of other summer-flowering plants that provide alternative sources of pollen. Root feeding begins immediately after plant emergence and early symptoms are expressed as drought or nutrient deficiency. Sites of larval damage are often pathways for infection by multiple pathogens, resulting in root putrefaction. They are found more in the corn plots with weeds compared to the plots without weeds. (Ioana Grozea et al.,2015)
Cutting the female flower can cause the reduction of grains in the cob, which can only be noticed at harvest time. Eggs are in the overwintering stage and are generally concentrated in the top 5-20 cm of soil, although they are located deeper in dry soils. Eggs require a period of cold-induced diapause before hatching, although a small portion of the population may hatch during a warm and prolonged fall. For the emergence of adults, about 415 degrees above 9°C are required in South Dakota, USA (Jackson and Elliot, 1988). In regions with warm, dry summers, the number of *Diabrotica virgifera* beetles drops rapidly in mid-August. Average lifespan decreases with increasing temperature from 13.8 weeks at 19.5°C to 7.9 weeks at 30°C (Elliott et al., 1990).
Diabrotica virgifera is on the quarantine list of EPPO and European Union Member States, the fact that *Diabrotica virgifera* spreads relatively slowly by natural means, except when carried by storms, offers some potential for its containment. (Furlan et al., 2002) However, the rate of spread still poses a serious threat to the whole Europe. In principle, all possible crops, fallows or vegetables can be replaced with maize for the management of *Diabrotica virgifera*. (Kiss et al., 2005a) However, certain crops, such as soybean or monocotyledon crops, may be less promising in long-term rotation with *Diabrotica* - infected corn fields. Many plants of the Poaceae family are known to serve to some degree as secondary food plants for *Diabrotica virgifera* larvae, and adults will feed on almost any pollen source. (Moeser and Hilbbard, 2005)

They deposit on average up to 500 to 1000 eggs for wintering, at a depth of 5-35 cm, most of them are placed at a depth of 15 cm. 3-5% of the eggs are laid on other plants. (Baca et al.,1995) Adult insects can live until mid-October. The adult insect can fly 40-80 km. The pest has one generation per year. The natural enemies of *Diabrotica virgifera* were surveyed in their area of

origin in Central America (Kuhlmann et al., 2005) and ***Celatoriacompressa*** was the only parasitoid found. The nematode species ***Heterorhabditisbacteriophora*** has been evaluated as a control agent and can achieve similar control efficacy to commercially available insecticide treatments (Toepfer, 2010).

The entomopathogenic fungi ***Beauveriabassiana*** and ***Metarhiziumanisopliae*** naturally attack *Diabrotica virgifera* (Toepfer and Kuhlmann, 2004).

Since *Diabrotica virgifera* is an actively moving beetle with the ability to mate throughout its lifespan, pheromonal control is limited. However, semi-chemicals have been used as insecticide baits (Metcalf et al., 1987). The pheromone for *Diabrotica virgifera* is (2R,8R) 8-methyl-2-decyl propanoate.

Chemical control mainly focuses on the larval stage of *Diabrotica virgifera* as it is more economically feasible. However, this strategy protects roots within the treated zone in the cornrow but does not reduce larval populations that complete their development outside the treated zone on peripheral roots. (Gray et al., 2006) Tillage practices do not appear to affect the distribution of insecticides in the soil profile. (Felsot et al., 1990) Soil treatments with granular or liquid formulations are dominated by organophosphates and synthetic pyrethroids or by a combination of the two classes of insecticides. (Gassmann and Weber, 2013)
Organophosphates, such as methyl-parathion, can still provide effective control of *Diabrotica virgifera* larvae and adults in the European invasive outbreaks studied. (M. Ciosi et al., 2009) Corn hybrids treated with *Bacillus thuringiensis Berliner toxins* (Bt) are commonly used by growers to manage this pest. (Calles et al.,2019). The corn rootworm is gaining ground against genetically modified crops designed to kill it, marking a setback for biotech seed producers. (Jacob, Bunge 2014) 8 - 10 larvae per root cause economic damage to corn at 60,000 plants per hectare (Toepfer and Kuhlmann, 2004) In the root damage rating system, a value of 2.5 or 3 on the traditional IOWA scale is considered economic damage.
0.75-1 adults per plant on average must be recorded several times from mid July to early August to meet the economic threshold needed to control *Diabrotica virgifera* in the following year. In general, a catch of 5 adult beetles per trap per day for each sampling period is an indication of potential economic rootworm damage if corn is planted in the field the following season. (Ronald B et al.,2007).

MATERIALS AND METHODS

The monitoring of this pest was carried out in block no. 16 in village Drithas, Municipality of Maliq. The soils planted with maize were mainly medium peat and sub-clay. The field was planted was corn the previous. These plots have been planted for 20 years with only corn monoculture.
Corn planting began after April 15, germination took place in early May, and was harvested from October 25th to November 15th. The cultivars planted and monitored were the four most widespread cultivars and occupy the largest areas in the planting structure. Medium-cycle cultivars such as Dumre extra 550 Fao, Dumre plus 500 Fao, and Myzeqeja 330 Fao, while long-cycle mainly Pioneer 630 Fao. Monitoring for eggs and larvae was carried out only on the cultivar Pioneer 630 Fao while monitoring for adults was carried out on all four cultivars.

Monitoring of larvae: To monitor the larvae of the diabrotica, on June 1, on an area of up to 5 ha, 10 corn roots were randomly selected and the root system with a diameter of 25 cm at a depth of 30 cm was dug with a shovel. Larvae were counted by hand on black plastic sheets.
Pupae monitoring: Their monitoring began after July 5 and was carried out in the same way as larval monitoring.
Assessment of damage to the root system: At the beginning of July, 10 corn roots were collected, shaken off the soil and dirt, washed to make them clean, and an assessment of the intensity of damage was carried out. Root damage was graded using the Iowa State University Scale (1 – 7 scale)
Scale 0 = no damage.
Scale 1 = There is no visible damage or only some minor signs of damage.
Scale 2 = Visible signs of damage are present, but no roots are eaten up to 4 cm, or with one or two shortened roots.
Scale 3 = Some roots eaten up to 4 cm from the plant
Scale 4 = A completely destroyed root node
Scale 5 = Two root nodes completely destroyed
Scale 6 = Three or more nodes completely destroyed
The damage to the root system estimate expressed as a percentage is found using the formula:

$$Id = \frac{0*(n0)+1*(n1)+2*(n2)+3*(n3)+4*(n4)+5*(n5)+6*(n6)}{K*N} * 100$$

Id = Damage in %
0,1,2,3,4,5,6,7 = scale of damage
ni = the number of plants for each scale
K = total number of scales
N = the number of plants analyzed in total

Monitoring of adults: To monitor adults, yellow traps were used from the end of June 10 until October 15th, placing one piece in four plots, planted with the four main corn cultivars. Traps were placed at the corn cob level and changed every 4 weeks. Traps were monitored every two days to catch the first image and signal to start the chemical treatments. “Figure 1”.
Egg monitoring: During the period July 27 - October 15th, in plots infected with *Diabrotica virgifera*, monitoring of eggs in the soil was carried out at a depth of up to 30 cm. For this, in 10 points in a diagonal shape for an area of 5 ha, the roots were uprooted and shaken on a black plastic sheet, then with a shovel it was dug to a depth of 30 cm, throwing the soil separately again on the black plastic sheet. By crushing and breaking up the soil by hand, the eggs found for each root were counted. The data were recorded in a notebook to derive the root mean.

Figure 1. Yellow traps without bait

RESULTS AND DISCUSSIONS

On June 1, the first larvae appeared and continued until the end of July. The first pupae were found on July 5 and continued until August 15. Adult insects appeared on July 12 and continued until September 10. On average, 12 – 15 adults were counted in the yellow traps every two days. Lowes and highest maximal daily capture were 2-536 in 24 monitored fields (Bazok et al.,2021). After monitoring the eggs, larvae, and pupae, these data resulted in "Table. 1". 8 - 10 larvae per root cause economic damage to corn at 60,000 plants per hectare.

The damage intensity according to the calculation was 21.4%. "Table 2". To estimate high adult population levels and follow their temporal appearance, three methods are usually applied from late June to September or at least during the period just before the female flower emerges until the flower turns brown and dry. For the determination of economic limits, these methods must be applied after mid-July. Monitoring adults in one season gives a fairly good prediction of damage in the next season.

Chemical treatments were carried out with insecticides;

- Fastac (***a.i.Cypermethrin***), synthetic pyrethroid with broad control spectrum. Quick knockdown action; contact and ingestion against adults. Usage dose 0.2 l/ha, dissolved in 400 liters of water.
- Imidan 70W.(***a.i.Phosmet***: *N - (Mercaptomethyl) phthalimide S-(O,O - dimethyl phosphorodithioate*) using 2.2 kg/Ha.
  Spraying was carried out with spray pumps modified for treatments at the level of 2.3 m height.
- Kaisosorbie (***a.i. Lambda cyhalothrin***), contact preparation and internal action. Dose of use 0.25 kg/ha.
  Modified sprayer pumps were used by raising the sprayer stacks to a height of 2.3 meters, above the height of the male corn flower.

- **Table 1.** Number of eggs, larvae and pupae found in 10 roots analyzed

Crops	Number of eggs found	Average egg/root	Number of larvae found	Average larva/root	Number of pupae found	Average pupa/root
First	4		3		2	
Second	0		5		3	
Third	6		4		5	
Fourth	0		7		3	
Fifth	2		0		6	
Sixth	6	3.6	6	3.8	0	3.1
Seventh	0		4		5	
Eighth	8		3		2	
Ninth	5		6		0	
Tenth	5		0		5	
Total 10	36		38		31	

Table 2. Damage rate in 10 roots analyzed

Degrees of damage	Number of plants, according to the degree of damage	Degree
0	2	n_0
1	4	n_1

2	2	n_2
3	1	n_3
4	1	n_4
5	0	n_5
6	0	n_6
Total 7 = K	**10 = N**	**n_i**

CONCLUSIONS

Some of the most important conclusions of this experiment are listed below

- The practice of continuously planting maize in the same place is responsible for the expansion of the population of *Diabrotica virgifera*;
- Agricultural rotation of corn is the most effective way to prevent the establishment of this pest and prevent damage and possible yield loss;
- Corn growers are advised to rotate corn with alternative crops wherever possible. This helps break up the life cycle, as the larvae hatch in the spring from eggs laid in the soil;
- Next year's pest will starve if there are no corn roots available to feed on;
- Early plantings are considered best;
- The planting of transgenic cultivars have been shown to be resistant to it due to their tolerance;
- Circulation is particularly important where corn is grown near international airports;
- *Phosphororganic* preparations have been shown to be effective against it;
- Delayed planting can result in reduced root damage as larvae can only survive a few days without feeding on suitable hosts. If planting is delayed until early June, root damage is negligible;
- It is possible that *Diabrotica virgifera* is spread within Europe by shipments of corn crop;
- *Diabrotica virgifera* can be hosted on a limited number of plants of the Poaceae family;
- Fields of late-blooming corn are attractive to beetles and can be used as trap crops;
- Planting transgenic rootworm - resistant corn is another strategy for minimizing damage. BT corn is effective in reducing root damage and is safer and often cheaper than insecticide.

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