Research Journal of Agricultural Science, 55 (2), 2023; ISSN: 2668-926X

EFFICACY OF EGG-PARASITIC WASPS (*TRICHOPLUS CAPSELS*) IN THE INSECT PEST CONTROL OF SWEET CORN

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Abstract: *Pest management is one of the biggest challenges in the plant protection of sweet corn cultivation. The most destructive insect pests of sweet corn in Hungary are European corn borer (Ostrinia nubilalis Hbn.) and the corn earworm (Helicoverpa armigera Hbn.). Damage caused mainly by larvae. Chewed corn cobs are unmarketable, and a significant yield loss can also occur. Chemical insecticides control is the most widespread, but the demand for the use of the biological method is increasing. The aim of the present work is to compare the effectiveness of the conventional chemical method and the biological control by egg-parasitic wasps, Trichogramma pintoi, T. evascens (Trichoplus capsules) under operating conditions. The research was carried out in the growing season of 2019 and 2020 in the area of Csárdaszállás-Gyomaendrőd settlements (SE Hungary). We monitored the imagos of both species using pheromone and food traps. The number of damaged corn cobs was counted on the day of harvest in the sample areas. The cob damage ratio data were analyzed using the SPSS Generalized Linear Model using a One-way, Random Block Design ANOVA method. The number of H. armigera caught peaked at the end of July in both years, while O. nubialis only started to appear in the traps at that time. Chemical control was carried out twice in 2019, which was overall more effective than the Trichoplus treatment. The proportion of damaged corn cobs was 7.2% and 9.5%, which is a significant but not a large difference. Due to very rainy weather in 2020, only one insecticide treatment was performed in conventional cultivation. This did not provide adequate protection, the proportion of damaged corn cobs exceeded 20%. Biological control, which takes into account trap signalling, was more successful this year than chemical control, but even in addition, significant damage of nearly 15% occurred.*

Key Words*: cob protection, Trichogramma, sweet corn, insect pests*

INTRODUCTION

The amount of sweet corn production area shows a continuous increase in global terms. Hungary is of outstanding importance as the largest producer in Europe. Its cultivation area was not significant until the 1970s, but due to the increased needs of the canning industry, the production area continued to grow (HODOSSI, 2004). In Hungary, the cultivation of sweet corn produced in organic farming on an increasingly large area (AGRONAPLÓ, 2018).

The effectiveness of cultivation largely depends on weather and soil characteristics, cultivation technology and genotype. Yield can show large year to year variation. One of the reasons for this may be the presence of insects occurring in a given year and the severity of the damage caused by them. Plant protection is one of the most important elements of cultivation technology (KESZTHELYI, 2016).

The greatest danger to the yield of corn is the corn beetle *(Diabrotica virginifera LeConte)*, the European corn borer *(Ostrinia nubialis Hbn.)* and the caterpillars of the corn earworm *(Helicoverpa armigera Hbn.)*. In addition to yield loss, diseases caused by fungi attacking at the site of bites appear as indirect damage. In the case of sweet corn, not only quantity, but also quality and aesthetics play an important role in terms of marketability (DÖMÖTÖR, ET AL., 2002).

The corn earworm *(Helicoverpa armigera Hbn.)* is an insect pest previously known as a migratory species in Hungary. Its first record dates from 1869. It can feed on about 120 host plants, it is polyphagous animal. We cannot speak of its settlement in Hungary (KESZTHELYI, 2018). Its damage mainly affects the generative parts of the corn, caterpillars chewing on the crest and on the tube ends (SZEŐKE, 2001). In Hungary, the protection is suited to the population peaks experienced in the middle and end of summer (BALOGH et al., 2005). Dry warm weather conditions lead to an increase in the number of individuals, while wetter, cooler weather leads to a decrease in the number of individuals (BALOGH et al., 2004, 2008).

Our native insect species, the European corn borer *(Ostrinia nubialis Hbn.)* has sweet corn as its main food plant, and 240 other food plants are known. Its damage, the drilling of the leaves and the stem, disrupts the plant's nutrient circulation (BÁNATI et al., 2010). Chewing on the outside of the tube is less common (KESZTHELYI, 2004). Its area of distribution shows a different number of generations depending on its ecological characteristics. In the southern Alföld region, the bivoltine ecotype appears (NAGY, 1958) At Székkutas in Csongrád County, a second type of swarm with a peak swarm was identified, which (both in terms of swarming time and swarm number surpasses the first swarm at the beginning of summer) is due to the actual second generation (non-diapulsed larvae). The correlation between the temperature and the number of individuals was also proven here (KESZTHELYI,* 2004).

Pest management control: A number of control options are known for the two main pests and damage of sweet corn. The simplest and cheapest one is the agrotechnical protection. In this case, the removal of corn stalk residues from the field and clean plowing means perfect underrotation. Agrotechnical control includes appropriate stocking density, optimal sowing time, and NPK supply (KESZTHELYI et al., 2003).

We can reduce the number of pests in an environmentally friendly way with biological control. It can be achieved by using insect parasites *(Trichogramma* egg-eating species can be used), episites, entomopathogenic bacteria and fungi (KESZTHELYI et al., 2003). The majority of large agricultural farms use synthetic (chemical protection) pesticides (insecticides) during production. Pesticides accumulate in the environment and endanger biosphere, and they also have a harmful effect on human health. Food often contains several types of chemical residues (KESZTHELYI, 2017). Well-directed chemical control can directly prevent damage.

In case of exposure to pesticides, the probability of occurrence of nervous system diseases and tumor becomes higher. The introduction of organic farming and the avoidance of the use of synthetic plant protection products in the environment are crucial to mitigating the harmful effects. Organic farming is the least yield-oriented of the farming methods. The focus of its approach is the use of natural materials (DIVER et al., 2008)

The purpose of this work is to examine the degree of damage caused by the European corn borer and the corn earworm in organic farming and in a conventional farm in the northern part of Békés county under operating conditions.

MATERIAL AND METHODS

Location of the experiment

The study areas are located in the south-eastern part of Hungary in Békés county, near to settlements Csárdaszállás and Gyomaendrőd. The company Biocsárda carries out organic farming in Csárdaszállás. They have been cultivating sweet corn for 5 years on an area of 30-60 hectares each year. The company Kond Coop deals with conventional large-scale arable crop cultivation, its areas are located in Gyomaendrőd. The predominant soil type in the area is meadow chernozem rich in humus.

Figure 1. Geographical location of the experiment sites

Cultivation technologies

In the two years of the study, the pre-crop of the sweet corn was winter wheat. The types, dates and amounts of technological cultivation procedures are summarized in Table 1. From the point of view of the investigation, the method of protection against the pest is the most important. In the conventional treatment, AMPLIGO (chlorantraniliprole, lambda-cyhalothrin) plant protection treatment was used. In 2019, twice on July 26 at a dose of 0.25 l/ha and on August 8 at a dose of 0.3 l/ha. In 2020, on one occasion on August 12, sweet corn was treated at a dose of 0.25 l/ha. The date of the defense was determined on the basis of a visual inspection (while taking into account the data of previous years).

Table 1.

Cultivation technology in the test periods

Cultivation technology					
		Kond Coop Kft		**Biocsárda Kft**	
		2019	2020	2019	2020
Sowing time		jun. 02	may 29.	may 10.	may 15.
Resistance	MDMV	✓	✓	✓	✓
	Puccinia sorghi	✓		-	-
	Pantoea stewartii	✓	✓	✓	✓
	Bipolaris maydis	-	-	✓	✓
Stem number		65 000	61 000	68 200	67 000
Terracolo 95		200 kg/ha	-	-	-
NPK 8-21-21		-	250kg/ha	-	-
Green Active N28		-	-	150 kg/ha	-
BioFerKáli Sulphate		-	-	-	600 kg/ha
AMPLINGO		0.25 l/ha 0.3 l/ha	0.25 l/ha	-	-
Trichoplus		-	-	100 cap./ha	100 cap./ha
Irrigation		85 mm/2	40 mm/1	60 mm	20 mm
Yield average		**16 t/ha**	**12,7 t/ha**	**11,5 t/ha**	**14 t/ha**

The pre-crop of organically grown sweet corn was spelled wheat in both years. The difference between the two years is that a different yield enhancer was used in organic farming. While Green Active N28 (150 kg/ha) was used in 2019, BioFerKáli Sulphate (600 kg/ha) will be used in 2020. The result of the use of different yield boosters can be observed in the yield averages. There is no difference in plant protection. The time of protection is determined based on the catch data of pheromone and bisex traps. In both years, 100 *Trichoplus* (egg crawler, egg parasite) capsules were placed per hectare.

Weather conditions

The examination of weather conditions were based on daily temperature (average, minimum and maximum) and precipitation data from the HMS (Hungarian Meteorological Service) Körösladány station (station number 66103). In 2019, during the active phase of cultivation technology (between 05.10 and 08.24), the average temperature was 21.2°C and 212 mm of precipitation fell. In 2020, in the same cultivation technology stage (06.02 to 06.09), the average temperature was 21.1°C and a total of 318 mm of precipitation fell. In the second experimental year, the cultivation technology was delayed by one or two weeks due to the frosts in April, this shift can be observed in the cultivation technology. The appearance of pests is influenced by temperature. In these two test years, the average temperatures do not differ significantly, so this does not affect the number of pests and the degree of damage.

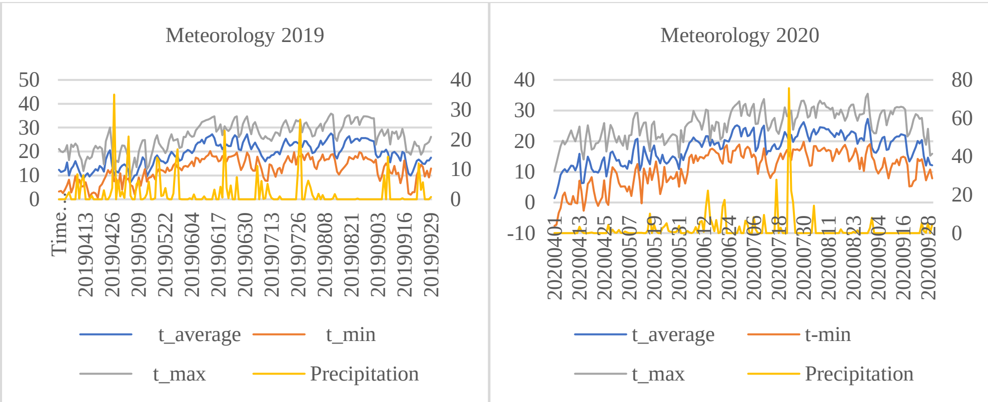

Figure 2. Temperature and precipitation data for the cultivation area (KÖRÖSLADÁNY, 2019, 2020)

Sampling method

In order to ensure the homogeneity of the sampling, 1-1 board was randomly selected from the entire area. In the following year, other boards were selected for the purpose of investigation. The boards were selected while excluding the edge effect. The signs were located at least 50 meters from the edge of the production area. Sampling was done from 5 plots within a field, for both treatments. The size of a parcel consisted of 5 rows, the length of which was 13.3 meters, which corresponded to 5 m^2.

Statistical methodology

The data from the sampling plots were collected in an Excel spreadsheet. We determined the rate of damage from the number of damaged cobs and all cobs. The data were analyzed using SPSS generalized linear model (GLM) one-factor random block design ANOVA. The dependent variable of the model is the rate of damage. Our model contains one factor, which is the type of treatment, and we distinguished two levels of this: conventional sweet corn cultivation and organic sweet corn cultivation. Two random blocks are included in the model, the sampling plots, the number of which (5) represent its levels, and the sampling time (2019 and 2020) are included with two levels. The structure of the model:

Damage ratio ~ treatment+plot+block+error

The condition tests of the analysis are the normality test to be performed on the error terms, which was accepted based on the results of the Shapiro-Wilk test W(100)=0.96; $p<0.01$. The distribution of the error terms is normally distributed (see Figure 3), one outlier data is shown. This data comes from the conventional treatment dataset in 2020 and shows a critically high damage rate. The homogeneity of the standard deviation of the data was accepted based on the Levene test F (19.80)=1.07; p=0.394.

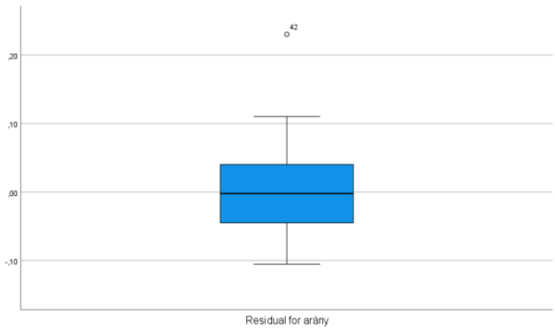

Figure 3. Normality of error terms

RESULT AND DISCUSSIONS

On 17 July, 2019, we placed the sex pheromone trap and the bisex traps near the ecologically treated field (Figure 4). The trap caught a large number of corn earworm *(Helicoverpa*) already on the day of placement. The catch data increased significantly in the following days. It reached its maximum on 25 July, which was 39 individuals. On 25 July, the *Trichoplus* capsules were placed. *Ostrinia* adults were found in small numbers on the 5th and 7th days after the trap was placed, and then their number continued to increase. In the conventional treatment, the first AMPLINGO insecticide treatment at a dose of 0.25 l/ha took place on 26 July. After that, on 8 August, the insecticide treatment was repeated at a dose of 0.3 l/ha.

In 2020, compared to the previous year, the traps were placed six days later. The sex pheromone trap placed on 23 July already caught more *Helicoverpa* individuals on the first day (39 individuals) than the number of individuals caught on the seventh day of the previous year (42 individuals). *Ostrini*a individuals were found on the 6th day after setting the trap. The placement of the *Trichoplus* capsules took place on 30 July. In the conventional treatment, the first protection was prevented by the heavy rainfall (76 mm) that fell on 27 July. The first spraying took place on 18 August at a dose of 0.25 l/ha.

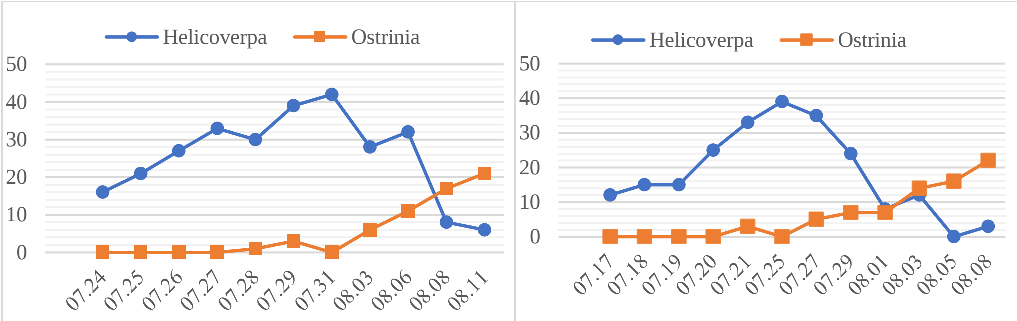

Figure 4. The number of *Helicoverpa* males and *Ostrinia* in 2019 and 2020, Csárdaszállás

Based on the yield results, the production of conventional sweet corn in 2019 was the most productive with a result of 16 t/ha. This was achieved with a higher number of stem number (65 000) and higher irrigation (85 mm). This high yield was achieved with significantly lower fertilizer use. In 2019 the cultivation technology was carried out exactly on time. In terms of yield in 2020, organic production showed a higher result of 14 t/ha (Tab 2.). Nutrient supply far exceeded the previous year. In terms of plant protection, it was the same in the two years. In the case of conventional treatment, neither the yield (12.7 t/ha) nor the plant protection was successful in 2020.

Table 2.

Average and standard deviation of the degree of damage in the breakdown of the examined years (from SPSS)

Rate of damage				
Year	Production	Average	Standard deviation	Plot number
2019	Conventional	0.0717	0.04200	25
	Ecological	0.0951	0.03108	25
2020	Conventional	0.2231	0.06866	25
	Ecological	0.1470	0.05720	25

The statistical evaluation of our test results shows that the treatment has a significant effect on the degree of damage F (1.93) =5,11; p<0.05, years and plots have no significant effect. Looking at the breakdown of the years, we also find that the effect of the treatments is significant. In the examined years, however, we can experience different degrees of damage, in 2019 the degree of damage is smaller F (1.44) =5.28; p<0.05. In 2020, the effect of damage is higher F (1.44) =18.36; p<0,001. This result is supported by the examination of the damage average. The averages of the damage rate show that the conventional treatment in 2019 showed the most effective result. The least effective treatment was also the conventional in 2020. Examining the cultivation technologies, the reason for this stems from the difference in the protection method in the two years. While in 2019 sweet corn received two plant protection treatments adapted to the gradation peaks, in 2020 plant protection interventions were carried out only for the gradation peak in August. In terms of the rate of damage, we do not see a big difference between the average values of the ecological treatment in the study years (Table 2).

CONCLUSIONS

During the period of the study, the two years showed similar temperature conditions. The number of pests (thus the effectiveness of the control) was similarly affected by the temperature. In the sweet corn production technology, the required amount of water was provided by irrigation. In 2020, a large amount of precipitation fell at the end of July, the spraying was postponed in time, thereby reducing the effectiveness of the protection.

The results of the two-year tests found conventional plant protection intervention to be the most effective treatment in 2019. At that time, the technology intervention was carried out properly. When the interventions were not regular (in 2020, the second spraying was missed), the highest damage rate was obtained.

In 2019, the organic treatment was more effective than the conventional treatment. In this year, the organic treatment produced similar results to the most effective conventional treatment.

In a two-year comparison of the ecological treatment, they showed almost the same effectiveness with each other and with the most effective conventional treatment. The minimal difference between the organic treatment of the two years can be explained by the one-week delay in sowing the second year.

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