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EFFECTS OF EUROPEAN CORN BORER CONTROL ON APHIDS AND THEIRS NATURAL ENEMIES IN MAIZE STANDS

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Abstract

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Over the period of July to September 2005 effects of insecticide Integro with the effective substance methoxifenozide and biological preparation Trichoplus using parasitoid wasps *Trichogramma evanescens* and *T. pintoi* were evaluated in maize stands. These natural enemies of aphids were recorded in monitored fields (located in South Moravia, Czech Republic): parasitoids of genera *Aphidius* and *Praon* (Hymenopetra, Aphidiidae), predatory syrphid flies (Diptera, Syrphidae), ladybirds (Coleoptera, Coccinellidae), Orius bugs (Heteroptera, Anthocoridae), Green Lacewing – *Chrysoperla carnea* (Neuroptera, Chrysopidae) and spiders (Araneida). No significant difference ($T = 0.003$; $F = 4.894$; $P = 0.004$) in populations of aphids and their antagonists was found in the studied variants (Integro, Trichoplus). More remarkable differences were found only soon after spraying with Integro. Syrphid flies pupae decreased by 41% in the Integro variant, and by 13% in the Trichoplus variant. Ladybird larvae did not occur in the Integro variant after spraying, there where 0.12 ladybird larvae on plant in the Trichoplus variant. Number of ladybird adults increased from 0.01 to 0.53 individuals per plant in the Trichoplus variant, but from 0.03 to 0.1 individuals in the Integro variant. Number of ladybird pupae decreased from 0.32 to 0.02 pupae per plant in the Integro variant, but it has increased from 0.04 to 0.54 in the Trichoplus variant. Correlative relationship between ladybird adult growing coefficient and aphid populations in the Trichoplus variant was found.

maize, aphids, natural enemies, biological and chemical pest control, European corn borer, *Ostrinia nubilalis*

European corn borer, *Ostrinia nubilalis* (Hübner, 1796) is a common and very serious pest of maize. Its caterpillars feed off the maize stem core damaging cobs too. Secondary fungal diseases can appear (*Fusarium*) and increase mycotoxin content in maize plants. Mycotoxins have negative effect on food quality. Losses can be between 10 to 20% in the Czech Republic, however, 40% loss is not rare (KOCOUREK & ŘÍHA, 2004). Chemical control of European corn borer can be promoted by several insecticides with different effective substances. Populations of aphids can be decreased, but their antagonists can seriously decrease too after spraying one of these insecticides. Consequently, aphids can grow very rapidly (BAGAR, 2005). Aphids sucking plant juices disturb balance of growing substances and phytohormons in plants, consequently, growth is retarded, some deformations can appear and young plants can die. Aphids also spread different plant viruses (ROD et al., 2005), for example *Rhopalosiphum padi* spreading Maize Dwarf Mosaic Virus – MDMV (AGRIOS, 2005). Aphids move from harvested cereals to maize and wait there until new grass emerges on plough fields.

If populations of natural enemies are not affected by chemical insecticides, they are able to hold populations of aphids under economical level (ROD et al., 2005). Biological pest control based on *Trichogramma* wasps is the possible alternative of the chemical control of European corn borer. This biological pest control has not probably any negative influence on natural enemies including aphid antagonists.

The aim of this study is to evaluate the influence of biological and chemical control of European corn borer in maize on populations of aphids and their antagonists.

MATERIAL AND METHODS

Study was done under field conditions in a field of Bonagro Blažovice a. s. in land register of Jiříkovice (South Moravia). The field was divided into three parts. The first part (roughly 22 ha) was treated with biological control of European corn borer, second (roughly 17 ha) was treated by chemical control. The third part (roughly 6 ha) was situated between treated parts and it was non-treated.

Biological pest controlled part was treated with Trichoplus. It contains parasitoid wasps of the genus *Trichogramma* (*T. evanescens* and *T. pintoi*). Application was done according to the manual, based on European corn borer flight signalizations. Trichoplus was applied by hand on the 22nd and 29th June 2005.

Insecticide Integro was chosen for treating chemical pest controlled part. Integro is suspension concentrate containing methoxyfenozide like an effective substance. Methoxyfenozide is quite young; its first commercial use was in 1998. Methoxyfenozide belongs to the second generation of ecdysone agonists. It is not toxic for several kinds of beneficial insects (TOMLIN, 2000). Recommended amount of Integro against European corn borer is 0.5–0.7 $l.ha^{-1}$ in the Czech Republic. Spraying was done on July 14th 2005.

Evaluation was done only in treated parts. Non-treated part was used as a protection against diffusion of effects of both treated variants.

Ten groups, each per 10 plants, were chosen in each variant. These groups were spread in a diagonal pattern. The first group was placed on the margin of the variant and another one followed after 15 steps and 5 rows to the right.

Rose grain aphid (*Metopolophium dirhodum*), Grain aphid (*Sitobion avenae*) and Bird-cherry aphid (*Rhopalosiphum padi*) were quantitatively evaluated on chosen plants. These natural enemies of aphids were evaluated: parasitoids of genera *Aphidius* and *Praon* (Hymenopetra, Aphidiidea), predatory syrphid flies (Diptera, Syrphidae), ladybirds (Coleoptera, Coccinellidae), Orius bugs (Heteroptera, Anthocoridae), Green Lacewing – *Chrysoperla carnea* (Neuroptera, Chrysopidae) and spiders (Araneida). The interval between evaluations was from 9 to 13 days. Evaluations were done on these dates: 4th, 13th and 25th July 2005, 5th, 17th and 30th August 2005 and 11th September 2005.

Single development stages of Coccinellidae were evaluated individually. Eggs and larvae were evaluated in *Chrysoperla carnea*, pupae and larvae in *Syrphidae*, adults and larvae in *Orius* and a spiders. Populations of genera *Aphidius* and *Praon* were evaluated according to the number of aphids mummified by larvae of these parasitoids.

Acquired data were statistically processed by software CANOCO (TER BREAK, 1995) and software R-language (R FOUNDATION, 2006). Gradient analysis was done in CANOCO. Analysis of variance and correlation relationships were done in R-language.

RESULTS

General evaluation

According to the gradient analysis there was no significant influence of the used type of control on monitored species (T = 0.003; F = 4.894; P = 0.004), only spiders were significantly abundant in Trichoplus variant (Figure 1). Spiders' abundance began to be significantly higher from July 5 in this variant and the same trend remained until July 30 (Table I). Populations in both variants were stabilized on September 11 (Tables I and II). Population dynamics of spiders could be affected negatively by spraying.

Ahpids (Aphidoidea)

Aphids were in high numbers during the first two evaluations (July 4 and 13) in both variants. Their numbers were very low during further evaluations (July 25, August 5 and 17). Their abundance started to increase on August 30, mainly *Rhopalosiphum padi*. There was a difference in *R. padi* population already before spraying. There were 55 aphid individuals per plant on July 4 in the Trichoplus variant, in the Integro variant there were 171 individuals per plant. The difference increased on July 13 – Trichoplus 394 individuals per plant; Integro 988 individuals per plant (Table I and II). This difference could be caused by colonization from prime host plants, whose growth could be closer to the Integro variant. Cold weather probably caused very low abundances of aphid populations from July 25 to August 30.

Negative correlation was found between population growing coefficients of *Metopolophium dirhodum*, *Sitobion avenae* and number of ladybird adults and pupae (Table III). It means that with low abundance of ladybird adults population of both aphids is growing. This relationship was not found in the Integro variant, where it could be affected by the influence of spraying.

Ladybirds (Coccinellidae)

The amount of ladybird larvae had a growing trend during the first two evaluations in both variants, but this amount was lower in the Trichoplus variant, probably due to the lower amount of aphids in this variant. There were not any ladybird larvae 11 days after spraying (July 25) in the Integro variant, while there was 0.12 ladybird larva per plant in the Trichoplus variant (Table I and II). This situation shows a possible negative effect of spraying.

Amount of ladybird pupae had a growing trend before spraying as well. Significantly lower amount of ladybird pupae was during these two evaluations in the Trichoplus variant. Amount of ladybird pupae

increased from 0.04 to 0.54 pupae per plant eleven days after spraying in the Trichoplus variant, while it decreased from 0.32 to 0.02 in the Integro variant (Table I and II). Pest control statistically significantly affected the amount of ladybird pupae and highly statistically significantly the amount of ladybird larvae (Tables IV and V). It is likely that ladybird larvae died after spraying; therefore no pupae were developed in the Integro variant. A part of ladybird larvae finished their development and created pupae and thus the amount of ladybird pupae increased in the Trichoplus variant.

There were 0.01 and 0.03 ladybird adults per plant in the Trichoplus and Integro variant respectively one day before spraying (July 13). Amounts in both variants were higher during next evaluation (July 25). Growth was more rapid in the Trichoplus variant (Table I and II). High statistical influence of the combination protection and date was found (Table VI). Based on the facts described above, it seems that spraying has a negative effect on ladybird adults. A part of ladybird adults probably died due to spraying and a part of them migrated from the treated field due to a low level of pray number. Damage of a part of larvae and pupae caused by spraying could result in a lower amount of ladybird adults in the Integro variant as well.

Ladybird adults' growing coefficient was positively correlated to the size of all three aphid populations (Table VII). It means that aphids were suitable pray for ladybirds and ladybird adults were able to search actively for aphid colonies, which they consumed and laid their eggs inside colonies. No statistic evidence was found for this behavior in the Integro variant, it could be caused by spraying.

Syprhid flies (Syrphidae)

There were 1.28 syrphid fly larvae per plant in Trichoplus variant on July 13. Part of these larvae became pupae and there were 0.53 syrphid fly pupae and 0.15 syrphid fly larvae per plant in this variant by July 25 (Table I). Compared to Trichoplus variant, there was 1.54 syrphid fly larvae per plant before spraying (July 13) in the Integro variant, but there were only 0.27 syrphid fly pupae and 0.13 syprhid fly larvae per plant (Table II). This lower number of pupae was probably caused by higher level of larvae mortality due to spraying. This situation is confirmed by high statistically significant influence of chosen protection in particular dates on the amount of syrphid fly larvae and pupae (Table VIII and IX).

Parasitoids (*Aphidius* and *Praon*)

Parasitoids of genera *Praon* and *Aphidius* had the same abundances with growing trend in both variants. There were hardly any parasitoids on the 11th day after spraying in the Integro variant. This situation was caused by sudden elimination of aphids by spraying in this variant.

There were 0.28 *Aphidius* and 0.08 *Praon* individuals per plant on June 25. It means high decrease for both genera. There is practically zero abundance of parasitoids as well as in the Integro variant during another evaluation. Aphid abundance decreased continuously probably due to the weather in the Trichoplus variant, therefore there was some low presence of parasitoids on June 25 (Table I and II). Statistically significant influence of control on parasitoids populations was not found.

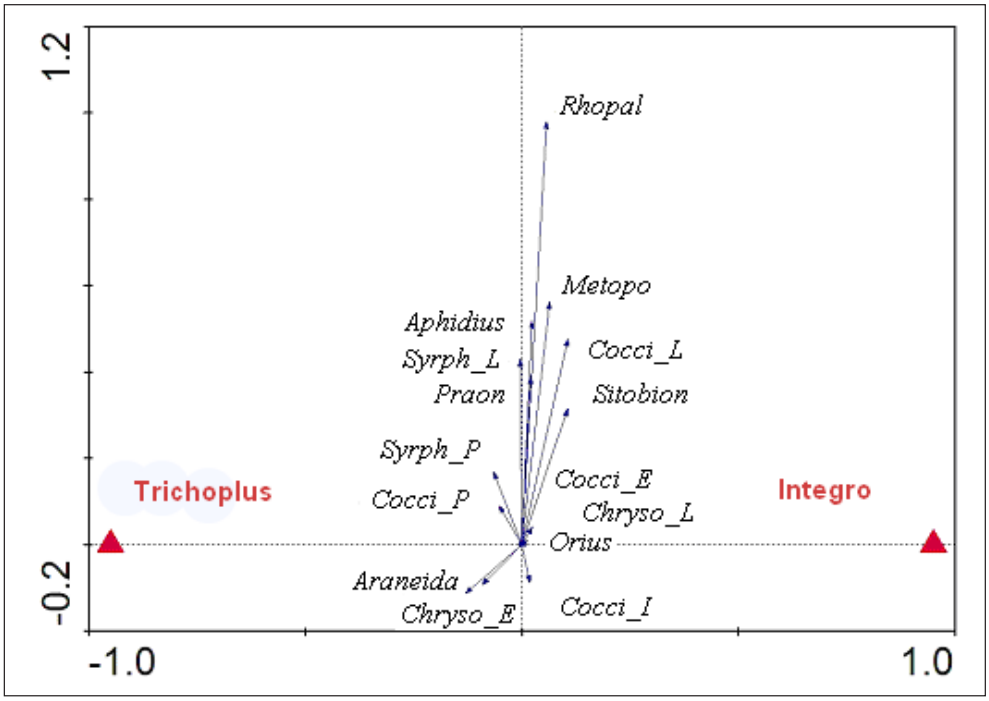
It is impossible to assess the influence of control on *Chrysoperla carnea* and species of the genus *Orius* from acquired data. It is due to the very low recorded numbers during all monitoring period.

DISCUSSION

HLUCHÝ (2005) did similar experiment in 2004, but in a minor scope. Aphids and their natural enemies were evaluated on thirty plants in each variant. First evaluation was before insecticide spraying and second and third was 15 and 35 days after spraying. Biological variant was treated with Trichoplus and chemical variant was treated with the insecticide Marshal 25 EC with effective substance carbosulfan. Similar situation was found on the 15th day after spraying, populations were negatively affected by spraying, but with stronger effect. Some populations were still under the negative effect on the 35th day after spraying. Significant differences were found in aphid abundances. There were only 0.2 aphids per plant in the Trichoplus variant, but on the other hand there were 550 aphids per plant in the Integro variant on the 35th day after spraying. JÜRGENS (1989) evaluated the effect of the substance deltamethrin on population of aphids and their natural enemies in maize field. Similarly to HLUCHÝ (2005), he found a high increase of aphid population after spraying.

Stronger effect of insecticide on aphids and their natural enemies found by HLUCHÝ (2005) was probably caused by lower selectivity of Marshal 25 EC compare to Integro. I did not find a big difference of aphid populations between variants after spraying. It could be caused by different course of weather in vegetation seasons 2004 and 2005, as in 2005 the weather conditions were not favorable for aphids. It is likely that the preparation Marshal 25 EC has a longer and stronger effect on population of natural enemies compared to Integro, therefore long-term low abundances of natural enemies allowed significant aphid gradation.

Based on the results, insecticide Integro could negatively influence populations of beneficial organisms. Larvae stages of ladybirds and syrphid flies seem to be most sensitive. It is confirmed by JÜRGENS (1989) who also found ladybirds and syrphid flies as most sensitive to insecticide. However, we cannot confirm that Integro caused low long-term population abundances of natural enemies, as it was found by HLUCHÝ (2005). Biological preparation Trichoplus did not have any negative influence on natural enemies of aphids.



1: *Statistic evaluation of affinity of aphids and their natural enemies to Trichoplus and Integro variants during July 4 to September 11 2005. (Gradient analysis). (T = 0.003; F = 4.894; P = 0.004) Legend: Aphidius = Aphidius; Msice_S = Rhopalosiphum padi; Kyj_O = Sitobion avenae; Kyj_T = Metopolophium dirhodum; Lacew_E = eggs of Green Lacewing; Lacew_L = larvae of Green Lacewing; Ladyb_I = adults of Ladybird; Ladyb_E = eggs of Ladybird; Ladyb_L = larvae of Ladybird; Ladyb_P = pupae of Ladybird; Orius = Orius bugs; Praon = Praon; Syrph_L = larvae of Syrphid flies; Syrph_P = pupae of Syrphid flies; Spider = Spiders.*

I: *Average numbers of aphids and theirs natural enemies in the Trichoplus variant (July 4–September 11, 2005)*

	Metopolophium dirhodum	Sitobion avenae	Rhopalosiphum padi	*Praon* spp.	*Aphidius* spp.	larvae of syrphid flies	pupae of syrphid flies	larvae of ladybirds	adults of ladybirds	pupae of ladybirds	eggs of ladybirds	spiders	Orius bugs	larvae of Green Lacewing	eggs of Green Lacewing
4.7.2005	461.93	22.56	54.51	1.08	2.46	0.44	0.02	0.14	0.04	0.02	0.76	0.09	0	0.02	0.01
13.7.2005	424.3	6.46	394.33	1.49	6.08	1.28	0.61	0.79	0.01	0.04	0.08	0.07	0	0.02	0.14
25.7.2005	0.04	0.01	0	0.08	0.28	0.15	0.53	0.12	0.53	0.54	0.05	0.02	0	0	0.64
5.8.2005	0	0.05	0.1	0.00	0.00	0.01	0.4	0	0.15	0.04	0	0.53	0.01	0.04	0.71
17.8.2005	0.01	0.02	0.22	0.00	0.01	0	0.06	0.01	0.04	0.01	0	1.17	0.01	0.05	0.45
30.8.2005	1.33	0.01	50.21	0.00	0.02	0.04	0	0	0.03	0	0	2.58	0.32	0	0.44
11.9.2005	25.94	0.23	405.88	0.00	0.00	0.46	0	0.04	0.03	0	0	1.28	0.08	0.01	0.13

II: *Average numbers of aphids and their natural enemies in the Integro variant (July 4 – September 11 2005)*

	Metopolophium dirhodum	Sitobion avenae	Rhopalosiphum padi	*Praon* spp.	*Aphidius* spp.	larvae of syrphid flies	pupae of syrphid flies	larvae of ladybirds	adults of ladybirds	pupaae of ladybirds	eggs of ladybirds	spiders	Orius bugs	larvae of Green Lacewing	eggs of Green Lacewing
4.7.2005	452.04	37.48	170.51	1.1	2.76	0.19	0.01	0.91	0.08	0.05	1.1	0.15	0.04	0.02	0.1
13.7.2005	687.65	28.74	988.22	1.81	7.03	1.54	0.46	1.14	0.03	0.32	0.51	0.13	0.04	0.01	0.07
25.7.2005	2.9	0.03	1.04	0	0	0.13	0.27	0	0.1	0.02	0	0.03	0	0	0.35
5.8.2005	0.86	0.01	4.11	0.01	0	0.01	0.17	0	0.36	0	0	0.04	0	0.05	0.23
17.8.2005	1.37	0	3.66	0.01	0.02	0.01	0.02	0	0.22	0	0	0.29	0.03	0.03	0.15
30.8.2005	14.56	1.25	81.49	0.02	0	0.31	0.01	0	0.1	0	0	1.39	0.19	0	0.29
11.9.2005	2.78	0.03	7.18	0	0	0.15	0.22	0.04	0.04	0	0	1.52	0.16	0.06	0.32

III: *Correlation of Methopolophium dirhodum and Sitobion avenae growing coefficients with numbers of ladybird's adults and pupae in the Trichoplus variant*

Methopolophium dirhodum	Pearson's correlation coefficient
Adults of ladybird	–0.9689**
Pupas of ladybird	–0.9974***
Sitobion avenae	
Adults of ladybird	–0.9689**
Pupas of ladybird	–0.9984***

IV: *Analysis of variance – larvae of ladybirds*

Sources of variance	Df	SS	MS	F value	Significant	
protection	1	7.00	7.00	23.6712	1.296e-06	***
date	6	169.73	28.29	95.6493	< 2.2e-16	***
plant	198	60.74	0.31	1.0373	0.3578	
protection: date	6	29.49	4.92	16.6213	< 2.2e-16	***
residuals	1188	351.35	0.30			

Signif. Codes: 0,1^{-3} (***), 0.001 (**), 0.01 (*)

V: *Analysis of variance – pupae of ladybirds*

Sources of variance	Df	SS	MS	F value	Significant	
protection	1	0.483	0.483	5.0003	0.02553	*
date	6	14.764	2.461	25.4823	< 2e-16	***
plant	198	23.220	0.117	1.2144	0.03172	*
protection: date	6	17.087	2.848	29.4914	< 2e-16	***
residuals	1188	114.720	0.097			

Signif. Codes: 0,1^{-3} (***), 0.001 (**), 0.01 (*)

VI: *Analysis of variance – adults of ladybirds*

Sources of variance	Df	SS	MS	F value	Significant	
protection	1	0.071	0.071	0.5235	0.4695	
date	6	15.994	2.666	19.5382	<2e-16	***
plant	198	26.374	0.133	0.9763	0.5770	
protection: date	6	13.349	2.225	16.3063	<2e-16	***
residuals	1188	162.086	0.136			

Signif. Codes: 0,1^{-3} (***), 0.001 (**), 0.01 (*)

VII: *Correlation of ladybird adult growing coefficient with numbers of aphid's populations in the Trichoplus variant*

Adults of ladybird	Pearson's correlation coefficient
Metopolophium dirhodum	0.9963***
Sitobion avenae	0.9957***
Rhopalosiphum padi	0.9937***

VIII: *Analysis of variance – larvae of syrphid flies*

Sources of variance	Df	SS	MS	F value	Significant	
protection	1	0.01	0.01	0.0248	0.8749	
date	6	287.01	47.83	103.7499	< 2.2e-16	***
plant	198	81.14	0.41	0.8889	0.8517	
protection: date	6	14.97	2.49	5.4109	1.573e-05	***
residuals	1188	547.74	0.46			

Signif. Codes: 0,1^{-3} (***), 0.001 (**), 0.01 (*)

IX: *Analysis of variance – pupae of syrphid flies*

Sources of variance	Df	SS	MS	F value	Significant	
protection	1	1.511	1.511	7.5200	0.006149	**
date	6	53.077	8.846	44.0134	< 2.2e-16	***
plant	198	51.286	0.259	1.2887	0.007504	**
protection: date	6	8.149	1.358	6.7571	4.695e-07	***
residuals	1188	238.774	0.201			

Signif. Codes: 0,1^{-3} (***), 0.001 (**), 0.01 (*)

We can not evaluate impact on *Orius* spp. due to the low numbers of these insects. MUSSER & SHELTON (2003) were observing the impact of selective insecticides on predators in sweet maize. They found a negative effect of full and half rate of lambda cyhalothrin on *Orius insidiosus*. They also found a negative effect of lambda cyhalothrin and indoxacarb on ladybird populations. Indoxacarb had no effect on ladybird adults. This confirmed that larva is the most sensitive stage in case of ladybirds.

CISNEROS et al. (2005) tried toxic effects of effective substance spinosad on predatory insects. The study was done in laboratory. Mortality in control *Chrysoperla carnea* larvae did not exceed 6% after 12 days, whereas mortality was moderately low in Spinosad treatments reaching 19% at 200 ppm and 34% at 2000 ppm Spinosad after 12 days.

It is evident that chemical insecticides have some negative influence on non-target species, including natural enemies of aphids. Influence can be differently intensive based on effective substance. Weather during the vegetative season plays some role in number of aphids during particular year. Influence of more insecticides with different effective substances on aphids and theirs natural enemies should be evaluated during several years in the future.

SOUHRN

Vliv ochrany proti zavíječi kukuřičnému na mšice a jejich přirození nepřátelé v porostech kukuřice

V průběhu července až září roku 2005 byl sledován vliv insekticidu Integro s účinnou látkou methoxifenozide a přípravku Trichoplus využívající parazitoidní vosičky *Trichogramma evanescens* a *T. piotoi* na populace mšic a afidofágů v porostech kukuřice. Ve sledovaných porostech na jižní Moravě se vyskytovali tito přirození nepřátelé mšic: mšicomaři rodů *Aphidius* a *Praon* (Hymenoptera, Aphidiidea), dravé pestřenky (Diptera, Syrphidae), slunéčka (Coleoptera, Coccinellidae), hladěnky (Heteroptera, Anthocoridae), zlatoočka obecná (Neuroptera, Chrysopidae) a pavouci (Araneida). Mezi sledovanými variantami (Integro, Trichoplus) nebyl zjištěn výraznější rozdíl ve výskytu afidofágů a mšic (T = 0,003; F = 4,894; P = 0,004). Pouze krátce po postřiku přípravkem Integro došlo k následující výraznější změně ve výskytu sledovaných afidofágů. V porostu došlo ke snížení výskytu kukel pestřenek o 41 %, ve variantě Trichoplus byl pokles pouze 13 %. Larvy slunéček se ve variantě Integro po postřiku nevyskytovaly vůbec, ve variantě Trichoplus jich bylo 0,12 na rostlinu. Počet imag slunéček vzrostl z 0,03 na 0,1 na rostlinu, ale ve variantě Trichoplus byl nárůst výrazně vyšší z 0,01 na 0,53. Množství kukel slunéček se snížilo z 0,32 na 0,02 na rostlinu, ale ve variantě Trichoplus došlo k nárůstu z 0,04 na 0,54. Je možné, že tyto rozdíly byly působeny aplikací přípravku Integro. V dalším průběhu sledování došlo k postupnému snižování rozdílu v množství sledovaných afidofágů mezi oběma variantami. Na základě získaných dat se také podařil prokázat pozitivní korelační vztah ve variantě Trichoplus mezi růstovým koeficientem imag slunéček a populací mšic.

kukuřice, ochrana rostlin, mšice, přirození nepřátelé mšic, zavíječ kukuřičný, *Ostinia nubilalis*

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