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BENEFICIAL ARTHROPOD COMMUNITIES IN COMMERCIAL POTATO FIELDS

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Abstract

In the frames of the F7P Project "Assessing and monitoring the impact of genetically modified plants on agro-ecosystems, (AMIGA)", the partner from Bulgaria was involved in monitoring and collecting data describing the arthropods communities, representative for five biogeographical regions of Europe.

Our investigations were focused on beneficial arthropod fauna in a typical potato region of Bulgaria (Samokov area). They were conducted in three consecutive years (2013–2015). Pitfall traps were used to study epigeic arthropod fauna and plant-dwelling arthropods were visually observed. The plant protection systems and meteorological data were documented.

Our monitoring of the biodiversity and abundance of natural inhabitants in a typical commercial potato plantation showed that pest management based on foliar or systemic application of chemical pesticides influence negatively the abundance of beneficial arthropod communities. These data could serve as a background to predict the potential impact of eventual changes in agricultural practices. In addition, our study contributes for the development of a database describing the various agricultural biogeographical regions at European level.

Key words: epigeic arthropods, foliar arthropods, foliar insecticides, systemic insecticide, rainfalls

Introduction. Arthropod biodiversity in every agro-ecosystem involves both beneficial and harmful insects from farmers' point of view. Predatory arthropods, such as ground beetles, ladybirds and spiders may play an important role in pest control. In addition, beneficial arthropods are an important link of the

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food chain and contribute for the ecosystem services (e.g. as pollinators). The monitoring of arthropods biodiversity and abundance in the agro-ecosystems is an essential element of the baseline conditions, typical for the respective biogeographical region.

In the frames of the F7P Project "Assessing and monitoring the impact of genetically modified plants on agro-ecosystems, (AMIGA)", the partner from Bulgaria was involved in work package focused on monitoring and collecting data describing the arthropods communities, representative for five biogeographical regions: Atlantic, Boreal, Continental, Mediterranean and Balkans. The output from the studies was expected to be a definition of region-specific database for the main arthropod functional groups, crop managements and environmental conditions for each region. This information could help to predict positive or negative effects of eventual changes in the agro-ecosystems. Our task was related to potato as an important crop. At present, potato producers often change insecticides and herbicides application. During last decades there are also significant climatic changes in our region.

The aim of our investigation was to describe the beneficial arthropod fauna of commercial potato fields and assess the effects of conventional cropping system and climate conditions on the arthropods communities. In this respect, we did our observations in the region of Samokov – a typical area of Bulgarian potato production. The most harmful pests in this region are the Colorado potato beetle (CPB) *Leptinotarsa decemlineata* (Say) as leaf destroyer [1] and the aphids *Myzus persicae* (Sulzer), *Macrosiphum euphorbiae* (Thomas) as vectors of viruses [2,3]. These are also the main targets of pest protection strategies used so far.

Materials and methods. Three consecutive years (2013 to 2015) we studied the arthropod fauna in conventional potato fields located in the Samokov region (South-western region of Bulgaria) at about 900 m a.s.l. The observations took place in plantations with area of 4 ha in 2013, 80 ha in 2014 and 50 ha in 2015, respectively, where commercial potato cultivars VR801 and Alexia were cultivated.

The arthropods were collected from 10 pairs of pitfall traps [4] three times in a season (June, July and August). The traps were laid and left for one week each month. They were placed among the potato plants in the rows to keep them away from flooding. The pitfalls contain 70% ethylene glycol and a drop of detergent.

Foliar arthropods were detected visually on 100 plants (10 plants randomly selected around every pair of pitfall traps), six times per season. In addition, each plant was shaken into entomological net. The major pests – aphids and Colorado potato beetle were also monitored. Agrotechnics and plant protection as well as meteorological data (documented by weather station Decom®) were collected and summarized (Table 1, 2).

All collected specimens, from all pitfalls and during the whole period of the study were identified up to species and summarized in groups. The data obtained were analyzed using one-way analysis of variance (ANOVA). The results were evaluated by Tukey's post-hoc test.

Results. Colorado potato beetle is the major problem for potato production. In this respect, it was important for us to take into account the abundance of the pest during our study. There were no specimens caught in 2013 (Table 3). In all three months of the next year, however significant numbers of CPB occurred. In 2015 the pest was found only in June (Table 3).

The main representatives of the beneficial arthropod community in our observations were ground beetles (Carabidae) and spiders (Araneae), followed by rove beetles (Staphilinidae) and ant species (Formicidae) (Table 3). Only six specimens of click beetles were captured (in 2013).

Ground beetles. For all the 3 years of study, the predominant part of the Carabidae was caught in the first month of observation (Table 3). In 2013, their number decreased more than 3 times in July and remained statistically significantly low in August ($F_{2,27} = 48.69$, $p < 0.001$). In 2014 the differences between the numbers in the 3 months of observations were less evident (Table 3). Again, in June the Carabidae were about 30–40% more abundant than in July and August, respectively ($F_{2,27} = 3.625$, $p = 0.04$). The situation in 2015 was similar to that in 2014 (Table 3) ($F_{2,27} = 1.982$, $p = 0.1573$).

As a whole, the abundance of the ground beetles in 2013 was several times higher than that in the next 2 years of observations. This striking difference was mainly due to the large amounts of beetles in June 2013 when their abundance was about 4 times higher than in the respective initial months of observations in 2014 and 2015. Despite the large differences in total abundance of Carabidae there were no differences in the species diversity during the months in the years and during the years of investigations (Table 3).

Spiders. The dynamics of spiders' occurrence in the investigated potato fields was different. A severalfold, statistically significant increase of caught spiders occurred in August for 2013 and 2015, respectively ($p < 0.001$) (Table 3). In 2014 the abundances in the three months were relatively even. On the other hand, there were year-to-year differences in biodiversity of Araneae. While in the first year there was a steady increase in number of species' abundance, in the next 2 years the biodiversity remained practically unchanged. Interestingly enough, in the year with lowest total number of specimens caught, the biodiversity was the highest (Table 3).

Rove beetles and ants. In all 3 years of observations the number of Staphilinidae was always highest in June followed by decrease in the next two months (Table 3). In 2015 the total number of rove beetles was much higher than those in the first two years. On the other hand, the biodiversity followed an opposite tendency – the number of species increased from June to August during our study. There were practically no differences in the numbers of Formicidae specimens caught in the three years of our experiment (Table 3).

Table 1

Agrotechnics and meteorological data from potato fields in 2013–2015

Year	Month	Mean temp.	Rainfalls L/m^2	Days > 10 L/m^2 rain	Field Activity	Pitfalls exposure
2013	April	12.3 °C	12.3		Planting – 25th	
	May	16.6 °C	31.9			
	June	17.6 °C	140.2	10.–11.06.–38.6 27–30.06. – 80.6	Spraying 05. Calypso 13. Dursban 21. Actara	5–12.06
	July	20.7 °C	21.0	06–12. 07.–17.6	05. Picador 20. Actara	10–17.07
	August	22.8 °C	5.2		Harvesting – end of August	01–08.08.
2014	April	10.7 °C	150.5	16–20.04 – 76.1; 25.04.–38.0; 30.04.–13.6		
	May	14.3 °C	148.2	14–15. 05.– 23.8 27–30.05.– 94.9	Planting – 10-18.; Pesticide incorp. 10–18. Monceren	
	June	15.5 °C	151.6	04–5.06.–16.4 09.06.–37.8 15.06.–20.2 20.06.–16.2		10–17.06.
	July	17.0 °C	98.6	14.07.–25.0 22.07.–23.8 31.07.–15.2	01. Calypso 18. Agria	02–09.07.
	August	20.8 °C	23.6	01.08.–12.4	Harvesting end of August	01 – 08.08.
2015	April	10.7 °C	14.0		Planting, 15–20; Pesticide incorporation 15–20. Monceren	
	May	16.1 °C	82.0	07.05.–12.0 11.05.–40. 0 14.05.–14.0		
	June	18.0 °C	119.0	10–11.06.–30.0 18–19.06.–38.0 24.06.–32.0	Spraying 28. Proteus	10–17.06.
	July	23.0 °C	42	01.07.–14.0 31.07.–21.0	23. Agria	02–09.07.
	August	22.4 °C	84.0	05.08.–22.0 21.08.–45.0	Harvesting second half of August	01–08.08.

T a b l e 2

Pesticides used in commercial potato fields, growing rezones 2013–2015

Commercial name	Active substances	Concentration used
Calypso 480 SC	Thiacloprid (480 g/l)	100 ml/ha
Dursban 4E	Chlorpyrifos (480 g/l)	1000 ml/ha
Actara 25 WG	Thiamethoxam (250 g/kg)	70 g/ha
Picador 20 SL	Imidacloprid (200 g/l)	500 ml/ha
Monceren G 370 FS	Pencycuron 250 g/kg + Imidacloprid 120 g/kg	0.6 ml/kg potato tubers
Agria 1050	Cypermethrin 50 g/l + Chlorpyrifos 480 g/l	500 ml/ha
Proteus 110 OD	Delthamethrin 10 g/l + Thiacloprid 100 g/l	400 ml/ha

Plant dwelling arthropods. The beneficial arthropod community associated with potato leaves was mainly pollinators (fam. Apidae), ladybirds (fam. Coccinelidae) and spiders. There were single individuals of bugs (*Nabis* sp., and *Geocoris* sp.). The total foliar arthropods detected by visual observations did not differ significantly between months in 2013, in 2014 and in 2015 (Table 3). Weak statistical differences were obtained between the years of investigation due to higher abundance of foliar arthropods in 2014 and in 2015 ($p = 0.57$ post-hoc Tukey's) (Table 3). The number of species in 2015 was higher than in 2013 and 2014 due to the 12 species of family Halictidae.Species from this family were missing in the two previous years.

T a b l e 3

Arthropod fauna in potato fields in 2013, 2014 and 2015. Sp. – species; Spm. – specimens

Year	Period	Colorado Potato Beetle	Epigeic arthropods				Foliar arthropods	Total
			Carabidae	Araneae	Staphilinidae	Formicidae		
			Spm./Sp	Spm./Sp	Spm.	Spm./Sp	Spm./Sp	Spm./Sp
2013	5–12. June	0	802/18	43/6	96/4	31/10	22/14	994/52
	10–17. July	0	242/18	39/11	23/5	30/9	21/7	355/50
	1–8. August	0	324/14	614/18	47/10	26/7	26/6	1037/54
	Total	0	1368/28	696/24	166/14	87/14	69/16	2386/96
2014	10-17 June	63	153/17	77/15	52/8	10/3	61/12	353/55
	2–9 July	10	99/22	40/17	33/10	32/6	21/10	225/65
	1–8 August	33	85/16	35/14	28/12	37/5	44/6	229/56
	Total	96	337/28	152/38	113/19	79/9	126/17	807/111
2015	8–15 June	16	149/18	55/8	162/5	43/6	55/13	464/50
	7–14 July	0	93/17	89/10	67/4	16/5	56/9	321
	1–8 August	0	103/15	531/11	44/10	21/5	63/22	762
	Total	16	345/27	675/18	273/12	80/10	174/30	1547/97

Discussion. Colorado potato beetle is the major pest and as a rule the whole plant protection system is focused on it. In our case we have 2 alternative approaches. In 2013 five foliar sprayings with insecticides were performed (Table 2). In the next two years the systemic insecticide Monceren G was directly applied at sawing. In addition, two foliar sprayings were performed during vegetation period. The standard one (with leaf spraying) resulted in CPB-free potato fields (Table 3). The alternative approach with incorporation of pesticide at potato seeds sawing led to a significant increase of mature beetles caught especially in the first year of trial (2014).

The main target of our study was the behaviour of the beneficial arthropod fauna in a commercial potato field with appropriate pest control.

Carabidae are often considered as predominant group of beneficial arthropods in crop fields and in this respect, used as markers for sustainability of various plant protection strategies. For example, the application of carbofuran to control European corn borer (*Ostrinia nubilalis* Hubner) and CPB suppressed or even eliminated predator communities, including ground beetles, in eastern North Carolina. However, predators recolonized the fields within 1–2 weeks following insecticide's application [5]. There were no differences between the non-target impacts of transgenic potato and conventional plantations with systemic or foliar applied insecticides in small plots experiments [6]. The comparison of transgenic Bt potato plantations with conventional growing systems showed no impact of transgenic plants on the beneficial arthropod abundance and biodiversity [1]. On the other hand, the application of alpha cypermethrin and fipronil had a negative effect on the carabidae community.

Carabidae beetles were the predominant and highly diverse groups of beneficial arthropods found in our investigations, too. The various plant protection systems applied resulted in drastic decrease in 2014/2015 (about 4 times) of the number of specimens caught while the biodiversity appeared to be unchanged. Probably the application of the systemic pesticide Monceren G intoxicated the soil around the potato tubers and affected epigeic beetles.

Earlier, in the same region of Samokov [7] it was shown that epigeic spiders' populations were not affected by sprayings in potato fields. Our present observations confirm the relative insensitivity of spiders to plant protection systems involving both foliar and systemic application of insecticides. The dynamics at both species and specimen level was not changed – in both 2013 and 2015 the biodiversity was at the highest levels in August, as previously observed [8]. The lowest number of spiders caught in 2014 could be explained by the heavy rainfalls in this period.

Insecticides treatments and rainfalls had no effect on ants and no, or slight effect (in 2014) on rove beetles. The rove beetles abundance was highest in June and decreased in July and August and this trend is opposite to the trend in spiders abundance (Table 3).

The dynamics of foliar biodiversity has been shown to be negatively influenced by insecticide treatments in various crops [5, 6, 9]. The abundance of Coccinellidae was studied in Bt and non-Bt potato experimental fields in Bulgaria in 2000 and 2001 [10]. In the first year, non-Bt field was sprayed twice in the season by alpha cypermethrin. The abundance of aphidophagous coccinellidae strongly decreased immediately after the first treatment and remained unchanged for most of the season. Our present observations show that the abundance of foliar arthropods was at the lowest levels in 2013, when the plantations were 5 times sprayed with different insecticides. They were at a high extent in 2014 and 2015 when systemic insecticide and only two foliar sprays were used.

Pests and predator communities were evaluated in potato fields treated with broad-spectrum, selective or organic insecticides [11]. Total predators densities and densities of ground beetles, rove beetles and epigeic spiders were highest in organic fields and fields treated with selective insecticides, and lowest in fields treated with broad-spectrum insecticides. Foliage-dwelling spiders were highest in organic fields, too. Predator densities were high in organic fields, but the densities of the two most harmful pests – green peach aphid and CPB were also high. The best results were achieved by selective insecticides applications.

Sustainable alternatives from environmental and economical point of view to pest management with chemical insecticides for our region have shown to be the application of biopesticides in early season potato cropping [12,13] as well as the growing of Bt potato lines [1, 10].

Our three years monitoring of the biodiversity and abundance of natural inhabitants of commercial potato fields in the region of South-Western Bulgaria (Balkan biogeographical region) showed that pest management based on foliar or systemic application of chemical pesticides influences negatively the abundance of beneficial arthropod communities. These data could serve as a background to predict the potential impact of eventual changes in agricultural practices. In addition, our study contributes for the development of a database describing the various agricultural biogeographical regions at European level. A study, describing the arthropods biodiversity on species level is in progress.

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