ISSN 1644-0692
www.acta.media.pl

ACTA Acta Sci. Pol. Hortorum Cultus, 14(6) 2015, 39-54

THE OCCURRENCE OF APHIDS ON SWEET MAIZE IN SOUTH-EASTERN POLAND

Paweł K. Bereś

Institute of Plant Protection – National Research Institute in Poznań, Regional Experimental Station in Rzeszów

Abstract. In Poland sweet maize is a small-acreage crop, and because of this no complex plan for the protection of this plant against pests and other harmful organisms has been developed. Since the enforcement of integrated pest management (IPM) in the EU in 2014 the use of chemical control methods has to be supported by relevant data on the biology of the controlled pest. A very limited number of studies have been carried out in Poland on the harmful entomofauna of sweet maize, including aphids. Studies were carried out in 2009–2014 on a field of sweet maize (*Zea mays* L. var. *saccharata*), 'Candle' cultivar, in south-eastern Poland. In the study years the infestation with aphids was from very low to moderately high. Seven aphid species were identified on sweet maize. The above-ground plant parts were infested with *Rhopalosiphum padi* L., *Metopolophium dirhodum* Walk., *Sitobion avenae* F., *Rhopalosiphum maidis* Fitch., *Aphis fabae* Scop. and *Myzus persicae* Sulz. A small number of individuals representing *Tetraunera ulmi* L. were found on the root systems of plants. *R. padi* was the dominant aphid species in all study years. *M. dirhodum* and *S. aveane* occurred in lower numbers, while other aphid species formed single colonies. Aphids began to infest maize plants from the last ten days of April or from May, and ended feeding at the end of September or in the first half of October. Two or three peaks of mixed-species aphid populations were observed on sweet maize plants, with the first peak being the most abundant. Individual aphid species had from one to three population peaks on plants, but the general dynamics of insect occurrence was affected mainly by the two most abundant species: *R. padi* and *M. dirhodum*.

Key words: *Zea mays* var. *saccharata*, Aphidoidea, species composition

Corresponding author: Corresponding author: Paweł K. Bereś, Institute of Plant Protection – National Research Institute in Poznań, Regional Experimental Station in Rzeszów, Langiewicza 28, 35-101 Rzeszów, Poland, e-mail: beresp@iorpib.poznan.pl

© Copyright by Wydawnictwo Uniwersytetu Przyrodniczego w Lublinie, Lublin 2015

INTRODUCTION

Sweet maize (*Zea mays* L. var *saccharata*) in Poland is a small-acreage crop. In 2014 it was grown on about 8.000 ha^{-1}, of which about 85% was for the food industry and about 15% for the fresh produce market [Warzecha and Malinowski 2015]. Because of the small scale of cultivation, no integrated plan for the protection of sweet maize against weeds, diseases and pests has been developed, and this disables the effective protection of cob yield volume and quality.

In recent years pests have become a particularly important group of harmful organisms to sweet maize grown in Poland. This is largely attributed to the considerable increase in the acreage of fodder maize, which, since 2012, has reached over one million hectares [GUS 2013, Michalski 2015].

Particularly serious pests of sweet maize in Poland include *Oscinella frit* L. (Diptera) and *Ostrinia nubilalis* Hbn. (Lepidoptera) [Kunicki 2003, Waligóra et al. 2008, Nawrocka et al. 2011, Waligóra et al. 2011]. In North America, where sweet maize is a very popular vegetable, pests of economic importance include *Helicoverpa zea* Boddie (Lep.), *Spodoptera frugiperda* Smith (Lep.), Diabrotica spp. (Coleoptera), *Ostrinia nubilalis* Hbn. (Lep.), *Popillia japonica* Newman (Col.) and *Rhopalosiphum maidis* Fitch (Hemiptera) [Capinera 2001, Changying 2011, Bunn 2014].

To date, not much attention has been paid to the occurrence of aphids on sweet maize in Poland. This problem was only studied by Mazurek and Hurej [2000] in south-western Poland. In 1997–1999 the researchers found three aphid species: *Rhopalosiphum padi* L., *Metopolophium dirhodum* Walk. and *Sitobion avenae* F. feeding on sweet maize. Lisowicz [2001] reported that aphids are one of the major pests responsible for damage to fodder maize. Feeding of aphids disturbs water transport in plants, which is extremely dangerous in periods of draught, and decreases the level of chlorophyll in tissues, which in turn affects photosynthesis and nutrient uptake by plants [Mrówczyński et al. 2004, Sytykiewicz et al. 2013]. The indirect harmfulness of aphids is associated with the fact that by sucking tissue fluids they increase plant susceptibility to infection with pathogens [Lisowicz 1996]. Some aphid species can also be vectors for viruses infecting maize plants, e.g. maize dwarf mosaic virus (MDMV), but also viruses infecting cereals, e.g. barley yellow dwarf virus (BYDY) [Tu and Ford 1971]. Ruszkowska et al. [2012] indicated that maize fields may be emergence sites for new host races of *R. padi*, which proves inter-species differences between aphids concerning the development of diversified new forms of developmental races. New host races of *R. padi* and *Sipha* (*Rungsia*) *maydis* Pass., specialised on maize, have already been identified in Poland [Ruszkowska and Strażyński 2015].

The aim of this study was to evaluate the species composition and population dynamics of aphids, and to identify the optimal timing of aphid control on sweet maize.

MATERIALS AND METHODS

Studies were carried out in south-eastern Poland in 2009–2014 on a 1 ha^{-1} field of sweet maize, 'Candle' cultivar. In 2009–2010 the experiment was set up in the village of Terliczka (50°06'N, 22°05'E), and in 2011–2014 in the village of Nienadówka (50°11'N, 22°06'E). In both locations maize was grown in a monoculture. In the study years the sweet maize field was grown directly next to other vegetables, e.g. tomato, pepper, carrot, cabbage, green beans, sweet maize and beetroot. Crops grown next to the sweet maize fields included potatoes, winter wheat and spring wheat.

Observations on the occurrence of aphids were carried out from April to the end of maize vegetation, i.e. the end of October. In results, only the dates on which aphids were feeding on plants are presented. To identify the population dynamics of individual aphid species from seedling emergence (BBCH 10) to full kernel maturity (BBCH 97) [Adamczewski and Matysiak 2011] maize plants were regularly inspected every 7 days. For the purpose of the study, each time in 5 places of the maize field 2 random plants with roots were sampled diagonally (10 plants per fields), and transported in sealed containers to a laboratory, where live insects were counted. Root systems and above-ground plant parts were searched for the presence of aphids. For each replicate consisting of two plants the total number of individuals was counted and species composition was identified. The population dynamics of major aphid species infesting sweet maize is presented in this study as the mean number of insects per plant. The percent share of individual aphid species in the total population of aphids collected from plants is presented for the whole vegetation season of maize.

Weather data were acquired from a weather station of the Institute of Meteorology and Water Management – National Research Institute (IMGW – PIB), located in Jasionka, near Rzeszów, 2 km from the experimental field in Terliczka and 10 km from Nienadówka.

RESULTS

Figures 1 and 2 present the changes in weather parameters most important for the development of aphids.

Between mid-April and mid-May 2009 a persistent drought was observed, which delayed seed germination and plant growth. In the later period, relatively low temperatures and heavy rainfall slowed down plant growth and limited their infestation with aphids. Weather conditions began to improve from mid-June. The summer was moderately warm and relatively dry except for periods of heavy rainfall during the vegetation period.

In 2010, from mid-April to July, most days were with heavy rainfall. Moreover, from April to the end of May temperatures were relatively low and did not favour the development of plants and their infestation with aphids. The weather improved in July and August. During that period there was a clear increase in temperature, which for more than ten days was above 30^oC. High temperatures were combined with rainfall, particularly heavy in July. The temperature decreased in September and rainfall did not favour the feeding of aphids.

In 2011 daytime temperatures were relatively low until the last ten days of May, and they limited the growth of plants and aphid colonies. In the first ten days of May there were three nights when the temperature dropped below -2^oC. From the last ten days of June until the end of July there were days with heavy rainfall. Rainstorms with local hailstorms occurred in the first half of July, and this resulted in the decreased number of aphids on plants. The weather clearly improved in August, particularly in terms of higher temperatures. These conditions persisted until the end of the maize vegetation season.

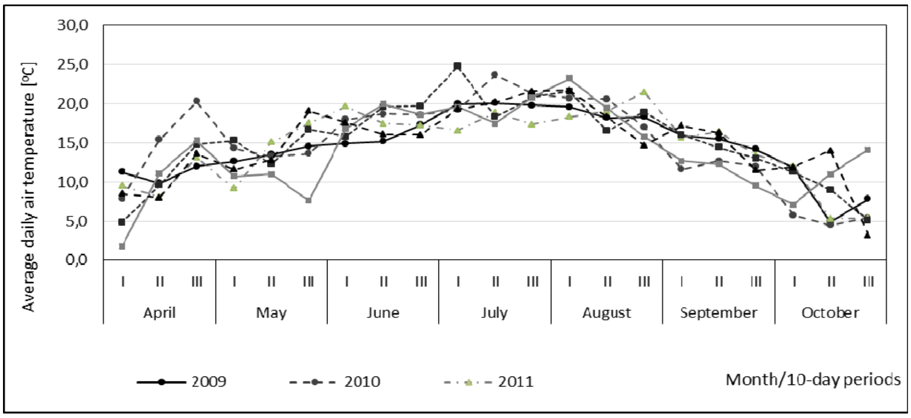

Fig. 1. Average air temperatures in individual 10-day periods in 2009–2014

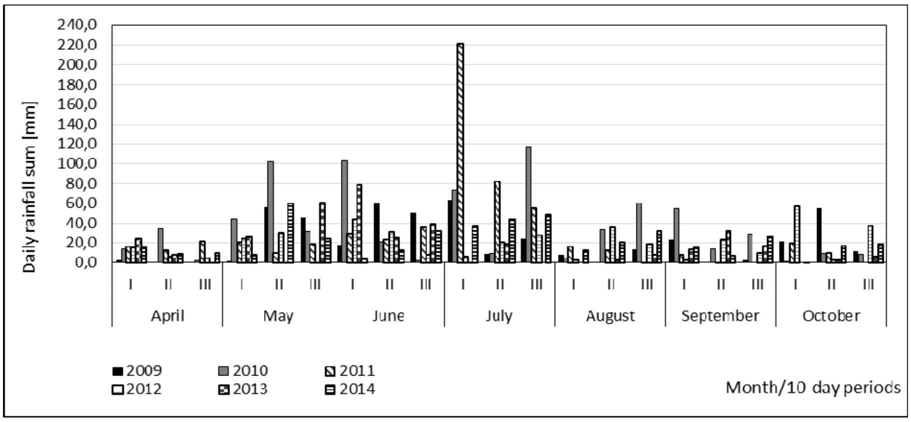

Fig. 2. Rainfall sum in individual 10-day periods in 2009–2014

In 2012, from early April to mid-May, there was a relatively low number of days with quite low temperatures (especially at night), and initially these conditions limited the intensive growth of plants and their infestation with aphids. In the second half of May a clear increase in temperatures favoured plant growth. 2012 was a relatively dry year.

In 2013, from May to early June, there were relatively many days with quite low temperatures (especially at night) and rainfall that limited the intensive growth of plants and their infestation with aphids. In the first half of July there were several nights with temperatures not higher than 10°C. From the end of July to mid-September prolonged water shortage occurred in the study area, and it accelerated maize ripening. In early October there was a several-day-long frost that completely inhibited plant growth.

In 2014, from the end of May to mid-June, there were many nights with low temperatures, which limited the intensive growth of plants and the development of aphid colonies. From July, temperature and rainfall favoured the growth of maize plants and their infestation with aphids.

Seven aphid species were identified on sweet maize plants (tab. 1). In all years the dominant aphid species was *Rhopalosiphum padi*, and it accounted for 66.8 to 82.2% (mean 74.8%) of the total population of gathered aphids. *Metopolophium dirhodum* was a much less abundant species, and it accounted for 11.1 to 28.8% (mean 20.9%) of the total aphid population. *Sitobion avenae* occurred in small numbers, and it accounted for 1.3 to 4.9% (mean 3.1) of the total population of identified insects, and *Rhopalosiphum maidis* – 0.1 to 1.9% (mean 0.7%). *Tetraunera ulmi* feeding on maize roots occurred in small numbers. On leaves single individuals representing *Aphis fabae* and *Myzus persicae* and other aphid species impossible to identify were found, and are categorized in the manuscript as "other". Aphid species from the category "other" accounted for 0.0 to 0.9% (mean 0.3%) of the total population of aphids caught in the study years.

Total population dynamics of the all aphids species and general population dynamics of the three most common aphid species: *R. padi*, *M. dirhodum* and *S. avenae* on sweet maize in 2009–2014 versus changes in weather conditions are presented in figures 3–8. Table 2 presents the dates of first occurrence, peak of occurrence and last occurrence of seven aphid species identified on maize plants.

Table 1. Percentage share of aphid species on sweet maize in 2009–2014

Year	Percentage share of the aphid population in the years (%)								Total number of caught aphids
	R. padi	*M. dirhodum*	*S. avenae*	*R. maidis*	*A. fabae*	*T. ulmi*	*M. persicae*	other	
2009	79.9	16.0	3.0	0.5	0.2	0.1	0.0	0.3	1660
2010	68.5	28.8	2.6	0.1	0.0	0.0	0.0	0.0	914
2011	82.2	11.1	4.9	1.9	0.0	0.0	0.0	0.1	696
2012	78.3	20.2	1.3	0.3	0.0	0.0	0.0	0.0	787
2013	73.0	21.6	3.9	0.8	0.1	0.2	0.1	0.3	1558
2014	66.8	27.6	2.7	0.6	0.4	0.7	0.4	0.9	7029
Mean/sum for years 2009–2014	74.8	20.9	3.1	0.7	0.1	0.2	0.1	0.3	12 637

In the study years the level of infestation of maize plants with aphids varied significantly. Very low numbers of insects were noted in 2011, low numbers in 2009–2010 and 2012, moderate in 2013, and moderately high in 2014 (tab. 1, figs. 3–8).

One of the factors affecting the population dynamics of aphids on maize in the study years was changes in weather conditions. The study revealed that during cold springs the infestation of plants with winged insects and the formation of colonies were limited, and later resulted in a reduced population of insects during the whole maize vegetation period. Changes in temperature during summer, combined with rainfall, also limited the

Table 2. Dates of first occurrence, peak of occurrence, and last occurrence of individual aphid species on sweet maize

Year	Observation	Dates of occurrence in the years							
		R. padi	*M. dirhodum*	*S. avenae*	*R. maidis*	*A. fabae*	*T. ulmi*	*M. persicae*	other
	A	27 May	17 Jun	17 Jun	17 Jun	25 Jun	07 Jul	–	17 Jun
2009		07 Jul	07 Jul	30 Jun	25 Jun	07 Jul	–	–	30 Jun
	B	12 Aug	–	–	–	–	–	–	–
		09 Sep	–	–	–	–	–	–	–
	C	23 Sep	09 Sep	30 Jun	30 Jun	07 Jul	07 Jul	–	30 Jun
	A	12 May	31 May	22 Jun	05 Jul	–	–	–	–
		05 Jul	13 Jul	05 Jul	05 Jul	–	–	–	–
2010	B	10 Aug	–	–	–	–	–	–	–
		02 Sep	–	–	–	–	–	–	–
	C	22 Sep	04 Aug	13 Jul	05 Jul	–	–	–	–
	A	09 May	07 Jun	13 Jun	28 Jun	–	–	–	13 Jul
		07 Jul	07 Jul	28 Jun	28 Jun	–	–	–	13 Jul
2011	B	16 Aug	07 Sep	–	–	–	–	–	–
		15 Sep	–	–	–	–	–	–	–
	C	28 Sep	15 Sep	24 Aug	13 Jul	–	–	–	13 Jul
	A	08 May	23 May	19 Jun	27 Jun	–	–	–	–
		04 Jul	04 Jul	04 Jul	27 Jun	–	–	–	–
2012	B	14 Aug	–	–	04 Jul	–	–	–	–
		26 Sep	–	–	–	–	–	–	–
	C	02 Oct	04 Sep	11 Jul	04 Jul	–	–	–	–
	A	14 May	21 May	18 Jun	25 Jul	25 Jun	02 Jul	02 Jul	25 Jul
2013	B	02 Jul	02 Jul	02 Jul	02 Jul	–	–	–	–
		21 Aug	–	–	–	–	–	–	–
	C	24 Sep	13 Sep	07 Aug	13 Aug	10 Jul	07Aug	30 Jul	16 Jul
	A	30 Apr	21 May	16 Jun	16 Jun	02 Jun	30 Jun	16 Jun	30 Jun
		07 Jul	07 Jul	07 Jul	14 Jul	14 Jul	07 Jul	07 Jul	14 Jul
2014	B	18 Aug	18 Aug	–	–	–	15 Sep	15 Sep	15 Sep
		15 Sep	15 Sep	–	–	–	–	–	–
	C	06 Oct	29 Sep	08 Sep	04 Aug	21 Jul	22 Sep	15 Sep	22 Sep

A – first occurrence, B – peak of occurrence, C – last occurrence intensive development of the aphid population. In addition, a significant effect of natural enemies on limiting the size of the aphid population was noted in all study years, and ladybirds (Coccinellidae), hoverflies (Syrphidae), lacewings (Chrysopidae), and parasitoids (especially Aphidius spp.) represented the most numerous enemies. The study did not identify any major factor with the strongest effect on the dynamics of the aphid population on plants in 2009–2014. Most likely, the mean infestation did not exceed 300 aphids per plant, i.e. the level that would justify the use of chemical control, because of the combined effect of many factors.

In 2009 the first aphids occurred on plants on 27 May. Because of the cold spring a significant increase in the aphid population occurred late, in the second half of June. Three clear peaks of mixed-species aphid populations were noted on sweet maize plants. The first and highest peak occurred on 7 July (mean 35.1 aphids/plant), the second peak on 12 August (mean 21.7 aphids/plant), and the third on 9 September (mean 15.7 aphids/plant). Insects ended feeding on maize on 23 September (fig. 3).

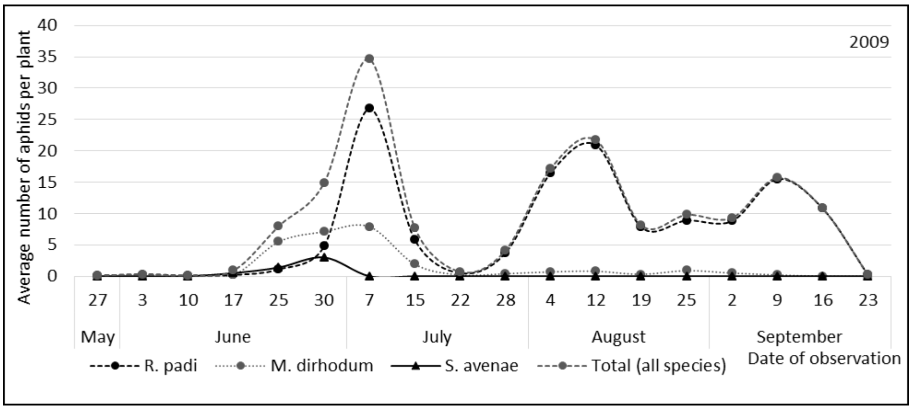

Fig. 3. Population dynamics of general and three most common aphid species on sweet maize in 2009

R. padi was the aphid species determining the dates of all the three population peaks. It infested maize plants from the end of May to the end of September. From the mid-June to early September the plants were infested with *M. dirhodum*. Between the end of June and early July low numbers of *S. avenae*, *A. fabae* and *T. ulmi* were found on plants. Small numbers of unidentified aphid species were also found in that period, but their number had no significant effect on the general population dynamics of insects (tab. 2).

In 2010 aphids began to infest maize plants on 12 May. Three population peaks were identified, with the first and highest on 5 July (mean 21.5 aphids/plant). The second peak of aphid population occurred on 10 August (mean 4.9 aphids/plant), and the third peak on 2 September (mean 6.0 aphids/plant). Insects ended feeding on maize on 22 September (fig. 4).

In 2010 the first population peak was determined by two aphid species: *R. padi* and *M. dirhodum.* The two other population peaks were determined by the presence of *R. padi.* Similar to the previous year, *R. padi* infested maize plants for the longest period (from mid-May to the end of September). *M. dirhodum* was recorded on plants from mid-May to early August, with one population peak, while *S. avenae* and *R. maidis* were found in small numbers in June and July (tab. 2).

In 2011 the first aphids occurred on plants on 9 May and ended feeding on 28 September. The population of insects was small for the whole maize vegetation period, but three population peaks were noted. The first and highest peak occurred on 13 July (mean 11.5 aphids/plant), the second peak on 16 August (mean 4.2 aphids/plant), and the third on 15 September (mean 9.1 aphids/plant) (fig. 5).

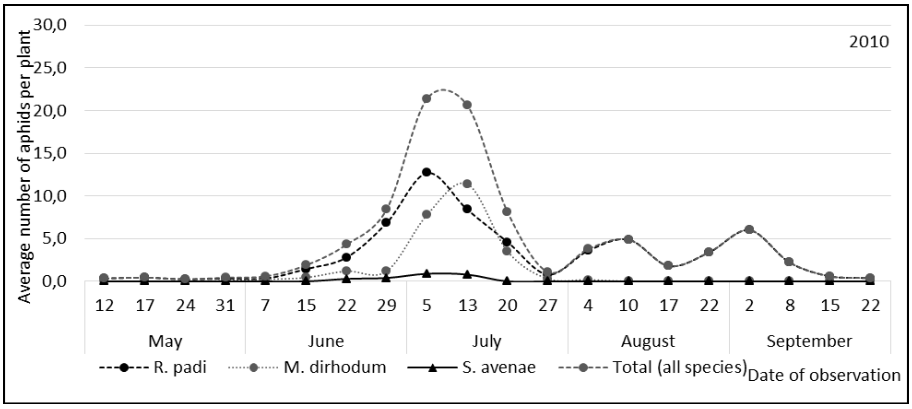

Fig. 4. Population dynamics of general and three most common aphid species on sweet maize in 2010

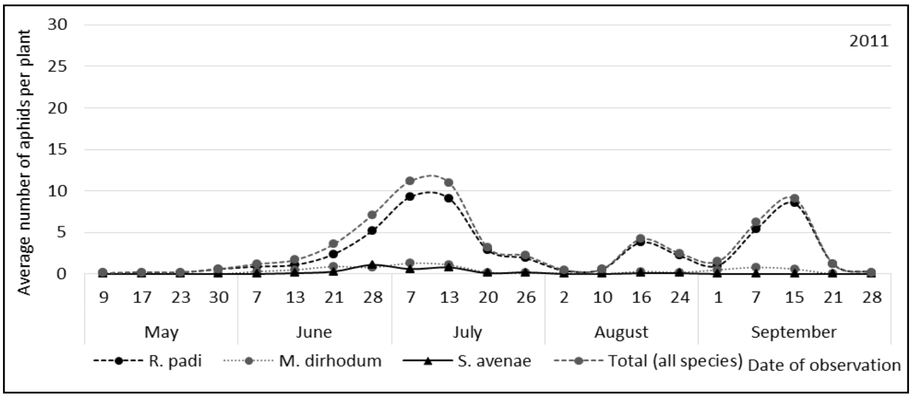

Fig. 5. Population dynamics of general and three most common aphid species on sweet maize in 2011

All three peaks of aphid population on plants noted in 2011 were determined by the presence of *R. padi*. Moreover, two minor population peaks of *M. dirhodum* were noted on 7 July and 7 September, but they had no significant effect on the general dynamics of aphid occurrence on sweet maize. *R. padi* and *M. dirhodum* infested maize plants for the longest period and ended feeding in September. *S. avenae* occurred in small numbers from mid-June to the end of August, while *R. maidis* fed on plants from the end of June to mid-July (tab. 2).

In 2012 aphids infested maize plants from 8 May to 2 October. Three population peaks were identified. The first peak on 4 July was the most pronounced (mean 22.5 aphids/plant). The other two population peaks occurred on 31 August (mean 3.7 aphids/plant) and on 26 September (mean 1.7 aphids/plant) (fig. 6).

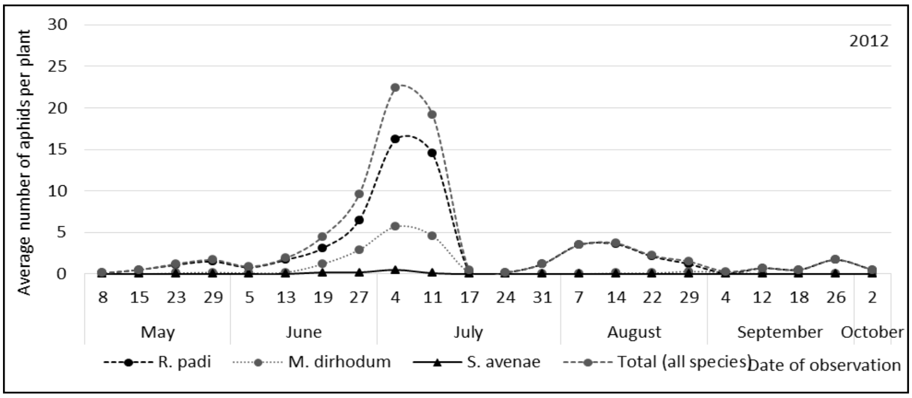

Fig. 6. Population dynamics of general and three most common aphid species on sweet maize in 2012

In the analysed year *R. padi* infested maize for the longest time (from May to early October) and had three population peaks. *M. dirhodum* also occurred for a relatively long time, and it infested plants from the end of May to early September, with one population peak. *S. aveane* and *R. maidis* occurred periodically from mid-June to mid-July. In 2012 *R. maidis* had two minor population peaks, on 27 June and 4 July (tab. 2).

In 2013 aphids infested sweet maize from 14 May to 24 September. Two peaks of mixed-species aphid populations were observed on sweet maize plants that year. The first and highest peak occurred on 2 July (mean 49.5 aphids/plant) and the second peak was on 21 September (mean 7.2 aphids/plant) (fig. 7).

In 2013, similar to previous years, *R. padi* infested maize for the longest period of time, from mid-May to mid-September and had two population peaks. *M. drihodum* fed on maize for a slightly shorter time, with one population peak in early July. *S. avenae* and *R. maidis* were identified on plants from mid-June to mid-August. Other aphid species found in small numbers from the end of June to early August were *A. fabae* and *T. ulmi*, as well as *M. persicae*, which occurred for the first time in the study area in July (tab. 2).

In the last study year (2014) aphids occurred in high numbers and infested plants from 30 April to 6 October. Initially, the size of aphid colonies increased very slowly. Rapid growth in the population of aphids on maize occurred as late as in the last ten days of June. In 2014 three peaks of mixed-species aphid populations were observed again on sweet maize. The first and highest peak occurred on 7 July (mean 197.3 aphids/plant), the second peak on 18 August (mean 44.5 aphids/plant), and the third on 15 September (mean 55.7 aphids/plant) (fig. 8).

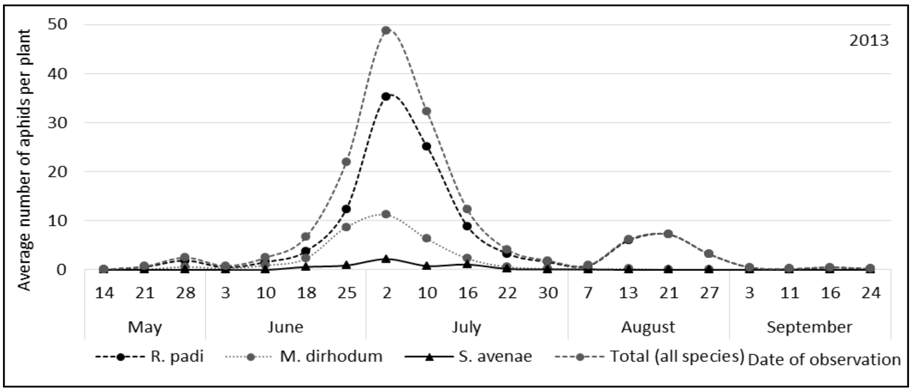

Fig. 7. Population dynamics of general and three most common aphid species on sweet maize in 2013

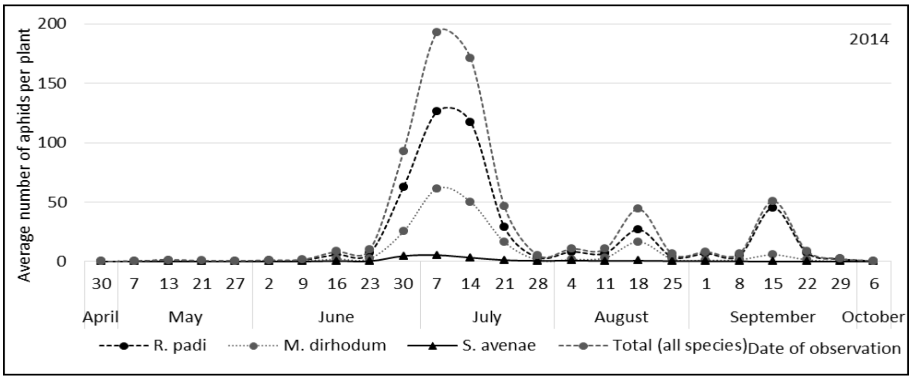

Fig. 8. Population dynamics of general and three most common aphid species on sweet maize in 2014

Similar to previous years, *R. padi* occurred on maize plants for the longest time, from the end of April to early October, and had three population peaks. *M. dirhodum* infested maize plants for a slightly shorter time (from the end of May to the end of September) and for the first time during the study had three population peaks concurrently with *R. padi*. In 2014, because of favourable weather conditions, other aphid species fed for a longer time on plants and infested them from early June to the end of September, depending on the species (tab. 2).

DISCUSSION

Seven aphid species (*Rhopalosiphum padi*, *Metopolophium dirhodum*, *Sitobion avenae*, *Rhopalosiphum maidis*, *Tetraunera ulmi* L., *Aphis fabae* Scop. and *Myzus persicae* Sulz.) were identified on sweet maize during the study. *R. padi* was the dominant species in all study years. The species composition of aphids identified on sweet maize did not differ, except for *M. persicae,* from the species composition of Aphidoidea found on *Zea mays* grown in Poland and other countries [Kania 1962a b, Pons et al. 1989, 1994, Krawczyk et al. 2008, Bereś 2011, Ruszkowska and Strażyński 2015].

Because of the limited number of reports from Poland on the species composition of sweet maize pests, the findings from our study could only be compared to observations made in the 1990s by Mazurek and Hurej [2000]. These researchers identified three aphid species on sweet maize in south-western Poland: *R. padi*, *M. dirhodum* and *S. avenae*, with *M. dirhodum* dominant. The same species were found in our study, but in the whole observation period *R. padi* was dominant.

Studies carried out on fodder maize provided more information on the species composition of aphids in Poland. The first studies in Poland on the harmful entomofauna of fodder maize were carried out in the 1950s by Kania [1962a b], who found five aphid species on fodder maize grown in south-western Poland. Observations demonstrated the feeding of *Macrosiphum euphorbiae* Thomas, *R. padi*, *R. maidis* and *A. fabae* on the above-ground plant parts, and *T. ulmi* on maize roots. In that period *R. padi* was the dominant aphid species on plants. A detailed faunistic study by Szelegiewicz [1968] on the species composition of aphids in Poland revealed the presence of eight aphid species, also reported as maize pests in other countries. These were: *A. fabae*, *M. euphorbiae*, *M. dirhodum*, *R. maidis*, *R. padi*, *Sipha* (*Rungsia*) *maydis*, *S. avenae* and *T. ulmi*. All these species except *M. euphorbiae* and *S.* (*Rungsia*) *maydis* were identified in our study on sweet maize.

Observations carried out in central Poland (Warsaw region) in 1979–1980 revealed the occurrence of two aphid species on fodder maize: *M. dirhodum* and *R. padi* [Kot and Bilewicz-Pawinska 1989]. Later studies by Pieńkosz et al. [2005] demonstrated that fodder maize near Warsaw was infested with four aphid species: *M. dirhodum, R. padi, S. avenae* and *R. maidis*, and the largest colonies were formed by *M. dirhodum.* The same species composition and dominance of *M. dirhodum* in captured material was also found for fodder maize in central-western Poland (Wielkopolska province) [Strażyński 2008]. Current studies on fodder maize grown in the Wielkopolska region demonstrated the presence of five aphid species on maize plants. The dominant species was *R. padi*, followed by *S.* (*Rungsia*) *maydis*, *R. maidis*, *M. dirhodum* and *S. avenae* [Ruszkowska and Strażyński 2015].

In south-eastern Poland studies carried out in 1982–2000 by Lisowicz [2001] showed two major aphid species on fodder maize: *R. padi* and *M. dirhodum*, and *R. padi* was the dominant one. Later observations in the same region of Poland carried out by Bereś [2011] demonstrated a more diversified species composition on fodder maize, including five species: *R. padi, M. dirhodum*, *S. avenae*, *R. maidis* and *T. ulmi*, with *R. padi* being the dominant one. The same species were found on sweet maize in the present study.

On the other hand, observations carried out by Krawczyk et al. [2008] in southern Poland near Opole indicated the presence of three aphid species on fodder maize: *R. padi, M. dirhodum* and *S. avenae*, with *R. padi* being the dominant one.

Our study and available reports indicated that the greatest risk to sweet and fodder maize in Poland is posed by two aphid species: *R. padi* and *M. dirhodum.*

In other European countries, e.g. Spain (Catalonia region), 12 aphid species were found on fodder maize, with three being the most abundant: *R. padi, S. avenae* and *M. dirhodum* [Eizaguirre and Albajes 1989, Pons et al. 1994, Asin and Pons 1999]. Other aphid species found in Catalonia included *M. euphorbiae*, *Metopolophium festucae*, *R. maidis*, *S.* (*Rungsia*) *maydis*, *Schizaphis graminum* Rondani, *Aphis gossypii* Gloger, *A. fabae* and *Hyalopterus amygdali* Blanchard [Pons et al. 1989, 2005]. In the USA one of the most important and abundant aphid species on maize is *R. maidis* [Carena and Glogoza 2004]. In our study on sweet maize *R. maidis* occurred in small number of colonies on plants. In the North America (USA) 13 aphid species have been found on maize: *Aphis craccivora* Koch, *A. fabae*, *A. gossypii*, *Aphis maidiradicis* Forbes, *Hysteroneura setariae* Thomas, *M. euphorbiae*, *M. dirhodium*, *M. persicae*, *R. maidis, R. padi*, *Sipha* (*Sipha*) *flava* Forbes, *S. graminum* and *S. avenae* [Stoetzel and Miller 2001]. Feeding of *M. persicae* on sweet maize was also confirmed in our studies.

In the USA *A. maidiradicis* is the most common aphid feeding on maize roots [Stoetzel and Miller 2001]. *A. maidiradicis* has not been reported from Europe. Studies in Poland, including those on sweet maize, revealed only the presence of *T. ulmi* on maize roots.

Findings from several-year-long studies on the dynamics of mixed-species populations of aphids on sweet maize demonstrated that in south-eastern Poland these insects began to infest plants as early as in the end of April, and continued feeding up to the first half of October. The duration of aphid occurrence on plants was determined by *R. padi*, which occurred at the earliest time and continued feeding until the maize plants dried out completely. The duration of occurrence of aphids on plants was much longer than that found by Mazurek and Hurej [2000] for sweet maize grown in south-western Poland, i.e. from mid-June to the end of July. Studies carried out in Poland on fodder maize in the last 30 years revealed that aphids began to infest maize plants in April, May or June, and continued feeding to September or October, depending on the year [Lisowicz 1992, Lisowicz 2001, Strażyński 2008, Bereś 2011].

The infestation of maize with aphids in the study years ranged from very low (2011) to moderate (2014), and this could be attributed to the combined effect of weather conditions and natural enemies of aphids. Lisowicz [1992] indicated that the colonization of maize by aphids is strongly influenced by temperature, rainfall, insolation and wind velocity. Another important factor determining differences in the size of the aphid population during the vegetation season is the presence of alternative host plants near maize fields, e.g. grasses and cereals, from where aphids can migrate to maize. Lisowicz [1992, 1996, 2001] also pointed out the significant role of natural enemies in limiting the population of aphids on maize, mainly larval forms of Coccinellidae and Syrphidae, but also, to a lesser extent, Chrysopidae and other aphidophages. Our study also demonstrated the emergence of large numbers of natural enemies of aphids during the formation of colonies by this pest, and their presence reduced the population of aphids in a short time.

Two or three population peaks were identified for the mixed-species populations of aphids on sweet maize, and in the whole analysed 6-year period the first peak was the highest. During that time it would be reasonable to carry out chemical pest control. Two population peaks in the development of aphids on fodder maize were observed by many authors, e.g. Kania [1962a b], Leisner et al. [1987], Plewka and Pankanin-Franczyk [1989], Jürgens [1989], Pons et al. [1989] and Lisowicz [1992]. Three population peaks were reported by Lisowicz [2001], Strażyński [2008] and Bereś [2011]. In some years aphids may have one population peak, as reported by Jürgens [1989] and Lisowicz [1992] for fodder maize, and Mazurek and Hurej [2000] for sweet maize.

In the analysed 6-year period the mean infestation with the pest did not exceed 300 aphids per plant, i.e. an economic injury level for maize that would justify the use of chemical pest control [Bereś and Pruszyński 2008].

CONCLUSIONS

1. Seven aphid species were identified on sweet maize, with *Rhopalosiphum padi* dominant.

2. Aphids began to infest sweet maize from the last ten days of April or from May, and ended feeding on plants in the end of September of in the first half of October.

3. The infestation of sweet maize with aphids during the study years was from very low to moderately high, and this can be attributed to changes in weather conditions and the activity of natural enemies.

4. Two or three population peaks were identified for the mixed-species populations of aphids, and peak dates and population sizes were determined by the dominant aphid species, *R. padi*.

5. *R. padi* had 2–3 population peaks, *M. dirhodum* 1–3 peaks, *R. maidis* 1–2 peaks, and other aphid species usually had a single, not very high population peak.

6. The first and highest peak of aphid population on plants was noted in the first half of July (2009–2014). The second population peak occurred either at the end of the first ten days of August (2009–2010), in the second ten days of August (2011–2012 and 2014), or in the early third ten days of August (2013). The third peak of aphid population was noted in early September (2009–2010), in mid-September (2011 and 2014), or at the end of September (2012).

7. The first half of July, when the first peak of insect population occurs, was found to be the optimal time for the chemical control of aphids on sweet maize.

REFERENCES

Adamczewski, K., Matysiak, K. (2011). Kukurydza. In: Klucz do określania faz rozwojowych roślin jedno- i dwuliściennych w skali BBCH. Wyd. III. Instytut Ochrony Roślin, Poznań, 27–30.

Asin, L., Pons, X. (1999). Effects of soil insecticide treatments on maize aphids and aphid predators in Catalonia. Crop Prot., 18, 389–395.

Bereś, P.K. (2011). The occurrence of aphids (Aphididae) on maize (*Zea mays* L.) in Krzeczowice near Przeworsk (south-eastern Poland) in 2005–2008. Acta Sci. Pol. Agricultura, 10(1), 3–12.

Bereś, P.K., Pruszyński, G. (2008). Ochrona kukurydzy przed szkodnikami w integrowanej produkcji. Acta Sci. Pol. Agricultura, 7(4), 19–32.
Bunn, B. (ed.) (2014). Utah vegetable production and pest management guide 2014. Utah State University Extension, Utah, 123 pp.
Capinera, J.L. (2001). Handbook of vegetable pests. Academic Press, New York, 729 pp.
Carena, M.J., Glogoza, P. (2004). Resistance of maize to the corn leaf aphid: a review. Maydica, 49, 241–254.
Changying, L. (2011). Commercial sweet corn production in Georgia. University of Georgia Cooperative Extension Bulletin, 1388, 48 pp.
Eizaguirre, M., Albajes, R. (1989). Present situation of arthropod pests in maize in the Northeast of Spain. Acta Phyt. Entomol. Hung., 24(1–2), 77–80.
GUS (2013). Wyniki produkcji roślinnej w 2012 r. Główny Urząd Statystyczny, Warszawa, 112 pp.
Jürgens, D. (1989). Auswirkungen eines großflächigen einsatzes von deltamethrin im mais auf spezifische prädatoren von blattläusen. Gesunde Pfl., 41(9), 320–325.
Kania, C. (1962a). Szkodliwa entomofauna kukurydzy obserwowana w okolicach Wrocławia w latach 1956–1959 (cz. I). Pol. Pismo Entomol., ser. B, 1–2(25–26), 53–69.
Kania, C. (1962b). Szkodliwa entomofauna kukurydzy obserwowana w okolicach Wrocławia w latach 1956–1959 (cz. II). Pol. Pismo Entomol., ser. B, 3–4(27–28), 183–216.
Kot, J., Bilewicz-Pawinska, T. (1989). Preliminary investigation of the maize entomofauna in the Warsaw region. Acta Phyt. Entomol. Hung., 24(1–2), 141–144.
Krawczyk, A., Hurej, M., Twardowski, J. (2008). *Rhopalosiphum padi* (Linnaeus, 1758) /Hemiptera, Aphidoidea/ anholo- and holocyclic forms' caught in yellow water traps. Aph. Other Homopt. Ins., 14, 129–134.
Kunicki, E. (2003). Uprawa kukurydzy cukrowej. Plantpress, Kraków, 95 pp.
Leisner, A., Ohnesorge, B., Wiener, G. (1987). Nebenwirkungen der deltamethrin-frühapplikation in mais zur bekämpfung des maiszünslers. Gesunde Pfl., 39(5), 174–183.
Lisowicz, F. (1992). Występowanie i efekty zwalczania mszyc (Aphididae) na kukurydzy (*Zea mays* L.) w rejonie Przeworska. Mat. XXXII Sesji Nauk. Inst. Ochr. Roślin, 1, 143–150.
Lisowicz, F. (1996). Teoretyczne i praktyczne podstawy zastosowania metod integrowanych w ochronie kukurydzy przed szkodnikami. Prace Nauk. Inst. Ochr. Roślin, 36(1/2), 5–46.
Lisowicz, F. (2001). The occurrence of economically important maize pests in south-eastern Poland. J. Plant Prot. Res., 4(3), 250–255.
Mazurek, J., Hurej, M. (2000). Aphids infesting sweet corn. Aph. Other Homopt. Ins., 7, 89–93.
Michalski, T. (2015). Uprawa kukurydzy doskonale się rozwinęła. In: Kukurydza – do niej należy przyszłość. Poradnik dla producentów. Wyd. VIII. Agroserwis, Warszawa, p. 3–8.
Mrówczyński, M., Boroń, M., Wachowiak, H., Zielińska, W. (2004). Atlas szkodników kukurydzy. Wyd. Inst. Ochr. Roślin, Poznań, 78 pp.
Nawrocka, B., Szafranek, P., Rybczyński, D., Wieprzkiewicz, A. (2011). Efektywność biologicznego środka ochrony roślin opartego na *Bacillus thuringiensis* var. *kurstaki* w zwalczaniu omacnicy prosowianki *Ostrinia nubilalis* Hübner na kukurydzy cukrowej. Now. Warzywn., 52, 25–31.
Pieńkosz, A., Leszczyński, B., Warzecha, R. (2005). Podatność kukurydzy na mszyce zbożowe. Prog Plant Prot/Post. Ochr. Roślin, 45, 989–992.
Plewka, T., Pankanin-Franczyk, M. (1989). Aphids and aphidophages on maize in Central Poland. Acta Phyt. Entomol. Hung., 24(1–2), 169–171.
Pons, X., Comas, J., Albajes, R. (1989). Maize aphids in the North-east of Spain. Acta Phyt. Entomol. Hung., 24(1–2), 173–176.
Pons, X., Asin, L., Comas, J., Albajes, R. (1994). Las especies de pulgones del maiz. Investigacion Agraria. Producc. Protecc. Veget., Fuera de Serie, 2, 125–129.

Pons, X., Lumbierres, B., López, C., Albajes, R. (2005). Abundance of non-target pests in transgenic Bt-maize: a farm scale study. Eur. J. Entomol., 102, 73–79.
Ruszkowska, M., Strażyński, P., Wachowiak, H. (2012). Preferencje pokarmowe mszyc na wybranych gatunkach zbóż. Prog. Plant Prot./Post. Ochr. Roślin, 52(4), 849–853.
Ruszkowska, M., Strażyński, P. (2015). Jesienna fauna mszyc na kukurydzy wskaźnikiem zmian środowiskowych. Prog. Plant Prot., 55(1), 83–86.
Stoetzel, M.B., Miller, G.L. (2001). Aerial feeding aphids of corn in the United States with reference to the root-feeding *Aphis maidiradicis* (Homoptera: Aphididae). Florida Entomol., 84, 83–98.
Strażyński, P. (2008). Aphid fauna (Hemiptera, Aphidoidea) on maize crops in Wielkopolska – species composition and increase in number. Aph. Other Homopt. Ins, 14, 123–128.
Szelegiewicz, H. (1968). Katalog fauny Polski. Mszyce. Aphidodea. PWN, Warszawa, 307 pp.
Sytykiewicz, H., Czerniewicz, P., Sprawka, I., Krzyżanowski, R. (2013). Chlorophyll content of aphid-infested seedling leaves of fifteen maize genotypes. Acta Biol. Cracov. ser. Bot., 55(2), 51–60.
Tu, J.C., Ford, R.E. (1971). Factors affecting aphid transmission of maize dwarf mosaic virus to corn. Phytopathol., 61, 1516–1521.
Waligóra, H., Skrzypczak, W., Szulc, P. (2008). Podatność odmian kukurydzy cukrowej na ploniarkę zbożówkę (*Oscinella frit* L.) i omacnicę prosowiankę (*Ostrinia nubilalis* Hbn.). Prog. Plant. Prot./Post. Ochr. Rośl., 48(1), 150–154.
Waligóra, H., Weber, A., Skrzypczak, W., Szabelska, A. (2011). Wpływ warunków pogodowych na uszkodzenia wybranych odmian kukurydzy cukrowej przez ploniarkę zbożówkę (*Oscinella frit* L.). Nauka Przyr. Technol. 5, 2, #10.
Warzecha, R., Malinowski, J. (2015). Do przetwórstwa i na świeży rynek. In: Kukurydza – do niej należy przyszłość. Poradnik dla producentów. Wyd. VIII. Agroserwis, Warszawa, 33–34.

WYSTĘPOWANIE MSZYC NA KUKURYDZY CUKROWEJ W POŁUDNIOWO-WSCHODNIEJ POLSCE

Streszczenie. Kukurydza cukrowa zaliczana jest w Polsce do upraw małoobszarowych, co ma swoje konsekwencje w braku kompleksowo opracowanego programu ochrony tej rośliny przed organizmami szkodliwymi, w tym przed szkodnikami. W związku z koniecznością stosowania od 2014 r. zasad integrowanej ochrony roślin (IPM), zastosowanie metody chemicznej musi być podparte znajomością biologii zwalczanego gatunku. Dotychczas w Polsce wykonano niewiele badań nad szkodliwą entomofauną kukurydzy cukrowej, w tym nad mszycami. Badania własne wykonano w latach 2009–2014 w południowo-wschodniej Polsce na kukurydzy cukrowej (*Zea mays* L. var. *saccharata*) odmiany Candle. W latach badań mszyce występowały w nasileniu od bardzo niskiego do średnio wysokiego. Zidentyfikowano siedem gatunków mszyc występujących na kukurydzy cukrowej. Nadziemne części roślin zasiedlały mszyce: *Rhopalosiphum padi* L., *Metopolophium dirhodum* Walk., *Sitobion avenae* F., *Rhopalosiphum maidis* Fitch., *Aphis fabae* Scop. oraz *Myzus persicae* Sulz. Na systemie korzeniowym roślin stwierdzono obecność nielicznych osobników *Tetraunera ulmi* L. Gatunkiem dominującym we wszystkich latach była mszyca *R. padi*. Mniej licznie wystąpiła mszyca *M. dirhodum* oraz *S. aveane*, natomiast pozostałe gatunki żerowały w pojedynczych koloniach. Mszyce zasiedlały rośliny od trzeciej dekady kwietnia oraz od maja, kończyły żerowanie pod koniec września lub w pierwszej połowie października. W rozwoju mieszanej populacji mszyc na kukurydzy cukrowej zaobserwowano występowanie dwóch oraz trzech szczytów liczebności owadów na roślinach, z których pierwszy był najliczniejszy. Poszczególne gatunki mszyc rozwijały od jednego do trzech szczytów liczebności na roślinach, przy czym na ogólną dynamikę występowania owadów wpłynęły głównie dwa najliczniejsze gatunki: *R. padi* oraz w mniejszym stopniu *M. dirhodum*.

Słowa kluczowe: *Zea mays* var. *saccharata*, Aphidoidea, skład gatunkowy

Accepted for print: 24.07.2015

For citation: Bereś, P.K. (2015). The occurrence of aphids on sweet maize in south-eastern Poland. Acta Sci. Pol. Hortorum Cultus, 14(6), 39–54.