ACTA Acta Sci. Pol., Agricultura 11(3) 2012, 3-16

DAMAGE CAUSED BY *Ostrinia nubilalis* HBN. TO FODDER MAIZE (*Zea mays* L.), SWEET MAIZE (*Zea mays* VAR. *saccharata* [STURTEV.] L.H. BAILEY) AND SWEET SORGHUM (*Sorghum bicolor* [L.] MOENCH) NEAR RZESZÓW (SOUTH-EASTERN POLAND) IN 2008-2010

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Abstract. The study was carried out on plants infested by the European corn borer (ECB) (*Ostrinia nubilalis* Hbn.): fodder maize Wilga cultivar, sweet maize Candle cultivar, and sweet sorghum Sucrosorgo 506 cultivar. Observations on the types of plant damage caused by caterpillars were carried out in 2008-2010 in south-eastern Poland, in Terliczka, near Rzeszów (50°06' N; 22°05' E). Damages caused by *O. nubilalis* varied according to plant species and weather conditions. The greatest harmfulness of ECB caterpillars during the analyzed three-year period was recorded in sweet maize, of which from 89.5 to 93.0% of plants, and from 53.5 to 76.0% of cobs were damaged. Lower harmfulness of the European corn borer was recorded in fodder maize, of which from 58.0 to 80.2% of plants and from 29.5 to 42.2% of cobs were damaged by caterpillars. Sorghum was the least infested and damaged species by *O. nubilalis*, with from 3.0 to 16.2% of its plants being damaged by caterpillars. Broken stems were the most common form of damage found in the analyzed plants. The greatest damage rate was found in sweet maize (34.7 to 66.7%), followed by fodder maize (29.7 to 52.5%), and a very low damage rate was found for sorghum (0.7 to 1.5%). The type of damage to maize and sorghum plants caused by ECB caterpillars largely depended on the number of pests. The highest number of caterpillars was found on sweet maize plants, while sorghum plants were infested only by single individuals.

Key words: European corn borer, harmfulness, maize, sorghum, host plants

INTRODUCTION

Fodder maize (*Zea mays* L.) is an increasingly popular plant grown in Poland, and the total area of land under cultivation in 2011 was 759 257 ha, of which 427 054 ha was grown for silage and 332 203 ha for grain [GUS 2011]. Sweet maize (*Zea mays* var.

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saccharata [Sturtev.] L.H. Bailey) is a much less popular plant, and in Poland it is used mainly in the food industry for consumption with or without processing. The acreage of its cultivation is about 5 000 ha [Waligóra and Skrzypczak 2012]. Sweet sorghum (*Sorghum bicolor* [L.] Moench) is a relatively new plant grown in Poland, and it is used as fodder, mainly in the form of green feeds, and for the production of silage. Sorghum is often grown in intercropping with fodder maize, but the current acreage of cultivation for this plant in Poland is unknown.

Fodder maize, sweet maize and sweet sorghum are attacked by the same pest – the European corn borer (ECB) (*Ostrinia nubilalis* Hbn.) [Poos 1927, Dicke 1932, Brindley and Dicke 1963, Calvin and Van Duyn 1999]. ECB is a polyphagous insect [Bengtsson *et al*. 2006], which infests many plant species from various families [Brindley and Dicke 1963]. Dicke [1932] and Lewis [1975] reported that in the USA the European corn borer feeds on about 200-233 farmed and wild-growing plant species.

In Poland ECB caterpillars have been found on fodder maize [Kania 1962a, b, Lisowicz 2003a] and sweet maize [Mazurek *et al*. 2003, Waligóra *et al*. 2008]. Also ECB was recorded on hops (*Humulus lupulus* L.) [Jastrzebski 1999], millet (Panicum spp.), mugwort (*Artemisia vulgaris* L.), sorghum (Sorghum spp.), italian millet (*Setaria italica* L.) and sugar beet (*Beta vulgaris* L. spp. *vulgaris*) [Kania 1961]. In addition, the feeding of ECB caterpillars inside vine stems (*Vitis vinifera* L.) was recorded for the first time in 2009 near Wrocław [Mazurek 2009].

However, as Poos [1927] and Brindley and Dicke [1963] reported, maize is the major feeding plant for *O. nubilalis*, and according to Häni *et al*. [1998] it allows for the mass reproduction of this pest.

The aim of present study was to compare the harmfulness of *O. nubilalis* caterpillars in three species of plants: fodder maize, sweet maize and sweet sorghum in south-eastern Poland, where one of the highest rates of ECB harmfulness has been recorded.

MATERIAL AND METHODS

Studies were carried out in 2008-2010 in south-eastern Poland, in Terliczka, near Rzeszów (50°06’ N; 22°05’ E) in conditions of natural pest infestation. Observations were carried out on early-maturing fodder maize of the Wilga cultivar, sweet maize of the Candle cultivar, and Sucrosorgo 506, a sweet sorghum cultivar. The experiment was established using the random block method in four replications. Each experimental plot was 200 m^2. Maize and sorghum were sown in the third ten days of April, and the plants were harvested in mid-October, without analysing the crop yield.

Observations on the harmfulness of the European corn borer to maize and sorghum were carried out on two dates:

– in the third ten days of August, when maize was at the dough ripening stage (BBCH 85) [Adamczewski and Matysiak 2011] the number of plants and cobs of fodder maize and sweet maize damaged by ECB were counted, as well as the number of broken tassels. For that purpose 100 randomly selected plants on each plot were analysed. In addition, 25 randomly selected plants from each plot were cut lengthwise to calculate the average number of caterpillars feeding inside the maize stems and cobs, the average number of holes in stems and cobs, and the number of feeding tunnels and their length. For sorghum, the number of plants damaged by caterpillars was counted, as well as the number of broken tassels, by

the analysis of 100 randomly selected plants on each plot. In addition, 25 randomly selected plants from each plot were cut lengthwise to calculate the average number of caterpillars feeding inside the stems, the number of holes inside the stem, and the number of feeding tunnels and their average length.
– in the first ten days of October, when maize was at the stage of full kernel maturity (BBCH 89), the number of stems broken below and above the cob, and the number of cobs gnawed at the base was calculated. The number of broken stems in sorghum plants was also calculated at the same time. Both for maize and sorghum the analysis was carried out for 100 plants on a plot.

Significant differences between average results were estimated using Tukey's test at a significance level of $P < 0.05$. Calculations were performed in Statistica© 10.0. software (license: Institute of Plant Protection-NRI, Regional Experimental Station in Rzeszów).

RESULTS AND DISCUSSION

Weather conditions during the study years with potential impact on the development and harmfulness of the European corn borer are presented in Table 1.

In the analysed three-year period the first individuals of *Ostrinia nubilalis* were recorded on the experimental field in mid-June, and caterpillars ended feeding in October, and thus weather conditions are presented only for the period in which the pest was found on plants.

In June and July, as Lisowicz and Tekiela [2004] and Bereś [2012] reported, moths of the European corn borer deposit eggs. Therefore, weather conditions during these months affect pest flight and oviposition, and, in consequence, the population of the species in a given vegetation season. In the study years both June and July were rainy, with the most intensive precipitation in 2010 (in total 326.3 mm for both months). Slightly lower precipitation during moth flight was recorded in 2009, with the lowest in 2008. Air temperatures in June and July were similar in all study years.

In August and September ECB caterpillars intensely feed on host plants. In the study years temperatures during this season were similar, but with respect to precipitation the wettest summers were recorded in 2010 and 2008.

The end of September and October are months when *O. nubilalis* caterpillars end feeding and begin wintering. Weather conditions during this period mainly affect the host plant and its maturing process, which is then decisive for the availability of food for the pest. Temperature is one of the key weather parameters affecting the feeding of ECB during that time. In the analysed three-year period the lowest temperature was recorded in October 2010, and the highest in 2008.

The harmfulness of the European corn borer varied between 2008 and 2010, and this was largely determined by weather conditions and the species of the studied plant. The greatest harmfulness of ECB caterpillars during the analyzed three-year period was recorded in sweet maize, of which from 89.5% (2010) to 93.0% (2008) of plants were damaged. Apart from damage to plants, the most important damage, from the economic point of view, was the feeding of caterpillars on cobs, which, as the commercial crop, must be free from any damage. In the study years the risk caused by *O. nubilalis* to the crop yield of sweet maize cobs was very high, with caterpillars damaging from 53.5% (2010) to 76.0% (2008) of these organs (Table 2).

Table 1. Weather conditions in 2008-2010 in Terliczka
Tabela 1. Przebieg warunków pogodowych w Terliczce w latach 2008-2010

Month Miesiąc	Weather parameters Parametry pogodowe	Decade – Dekada			Mean/Sum monthly Średnia/Suma miesięczna
		I	II	III	
2008					
June Czerwiec	daily average air temperature, ºC średnia dobowa temperatura powietrza, ºC	17.9	16.2	19.7	17.9
	rainfall sum – opady, mm	1.4	40.0	45.3	86.7
July Lipiec	daily average air temperature, ºC średnia dobowa temperatura powietrza, ºC	17.8	19.2	19.0	18.6
	rainfall sum – opady, mm	35.9	43.3	38.4	117.6
August Sierpień	daily average air temperature, ºC średnia dobowa temperatura powietrza, ºC	19.6	19.2	17.3	18.7
	rainfall sum – opady, mm	21.2	18.2	15.9	55.3
September Wrzesień	daily average air temperature, ºC średnia dobowa temperatura powietrza, ºC	19.3	9.0	10.7	13.0
	rainfall sum – opady, mm	5.0	84.1	14.1	103.2
October Październik	daily average air temperature, ºC średnia dobowa temperatura powietrza, ºC	10.9	11.0	9.8	10.5
	rainfall sum – opady, mm	39.4	10.7	5.9	56.0
2009					
June Czerwiec	daily average air temperature, ºC średnia dobowa temperatura powietrza, ºC	14.9	15.5	19.3	16.5
	rainfall sum – opady, mm	17.8	77.9	50.7	146.4
July Lipiec	daily average air temperature, ºC średnia dobowa temperatura powietrza, ºC	20.0	20.1	19.8	19.9
	rainfall sum – opady, mm	65.4	9.0	23.6	98.0
August Sierpień	daily average air temperature, ºC średnia dobowa temperatura powietrza, ºC	19.6	18.2	18.3	18.7
	rainfall sum – opady, mm	8.1	0.8	12.9	21.8
September Wrzesień	daily average air temperature, ºC średnia dobowa temperatura powietrza, ºC	15.9	15.5	14.2	15.2
	rainfall sum – opady, mm	22.7	0.0	2.8	25.5
October Październik	daily average air temperature, ºC średnia dobowa temperatura powietrza, ºC	11.8	4.9	7.8	8.1
	rainfall sum – opady, mm	20.9	55.6	11.7	88.2
2010					
June Czerwiec	daily average air temperature, ºC średnia dobowa temperatura powietrza, ºC	18.0	18.7	16.9	17.8
	rainfall sum – opady, mm	102.6	20.9	2.6	126.1
July Lipiec	daily average air temperature, ºC średnia dobowa temperatura powietrza, ºC	19.2	23.7	19.3	20.7
	rainfall sum – opady, mm	73.5	9.2	117.5	200.2
August Sierpień	daily average air temperature, ºC średnia dobowa temperatura powietrza, ºC	20.7	20.6	17.0	19.4
	rainfall sum – opady, mm	4.7	33.7	60.2	98.6
September Wrzesień	daily average air temperature, ºC średnia dobowa temperatura powietrza, ºC	11.6	12.7	12.0	12.1
	rainfall sum – opady, mm	55.1	13.7	28.7	97.5
October Październik	daily average air temperature, ºC średnia dobowa temperatura powietrza, ºC	5.7	4.4	5.4	5.1
	rainfall sum – opady, mm	0.5	8.9	8.4	17.8

Table 2. Percentage of damaged plants, cobs and stalks in 2008-2010
Tabela 2. Procent uszkodzonych roślin, kolb oraz łodyg w latach 2008-2010

Object Obiekt	% damaged % uszkodzonych		% of broken stalks % łodyg złamanych			% of broken tessels % złamanych wiech	% of cobs gnawed at the base – % kolb podgryzionych u nasady
	plants roślin	cobs kolb	below cob poniżej kolby	above cob powyżej kolby	total razem		
2008							
Fodder maize Kukurydza pastewna	80.2 a	45.0 a	15.7 a	36.5 a	52.5 a	15.2 a	4.7 a
Sweet corn Kukurydza cukrowa	93.0 a	76.0 b	28.7 a	32.2 a	60.9 a	21.7 a	13.2 b
Sweet sorghum Sorgo cukrowe	16.2 b	–	–	–	1.5 b	0.2 b	–
$LSD_{0.05}$ – $NIR_{0,05}$	sd – ri	sd – ri	ns – ni	ns – ni	sd – ri	sd – ri	sd – ri
2009							
Fodder maize Kukurydza pastewna	77.5 a	42.2 a	17.5 a	29.7 a	47.2 a	6.5 a	6.2 a
Sweet corn Kukurydza cukrowa	90.7 a	71.5 b	26.2 a	40.5 a	66.7 a	13.2 b	7.5 a
Sweet sorghum Sorgo cukrowe	13.5 b	–	–	–	0.75 b	0.5 c	–
$LSD_{0.05}$ – $NIR_{0,05}$	sd – ri	sd – ri	ns – ni	ns – ni	sd – ri	sd – ri	ns – ni
2010							
Fodder maize Kukurydza pastewna	58.0 a	29.5 a	9.2 a	20.5 a	29.7 a	7.0 a	2.2 a
Sweet corn Kukurydza cukrowa	89.5 b	53.5 a	11.5 a	23.2 a	34.7 a	9.2 a	5.5 a
Sweet sorghum Sorgo cukrowe	3.0 c	–	–	–	0.0 b	0.0 b	–
$LSD_{0.05}$ – $NIR_{0,05}$	sd – ri	ns – ni	ns – ni	ns – ni	sd – ri	sd – ri	ns – ni
Mean for 2008-2010 – Średnia z lat 2008-2012							
Fodder maize Kukurydza pastewna	71.9	38.9	14.1	28.9	43.1	9.5	4.3
Sweet corn Kukurydza cukrowa	91.0	67.0	22.1	31.9	54.1	14.7	8.7
Sweet sorghum Sorgo cukrowe	10.9	–	–	–	0.75	0.23	–

means followed by the same letter do not differ at 5% level of significance (Tukey's multiple range test) – średnie oznaczone tą samą literą nie różnią się na poziomie istotności 5% (test wielokrotnych porównań Tukeya)
sd – ri – significant differences – różnice istotne
ns – ni – non-significant differences – różnice nieistotne

Lower harmfulness of the European corn borer was recorded in fodder maize, of which from 58.0% (2010) to 80.2% (2008) of plants, and from 29.5% (2010) to 42.2% (2008) of cobs were damaged by caterpillars. Statistically significant differences in the percentage of plants damaged by ECB between fodder maize and sweet maize were recorded only in 2010, while statistically significant differences in the percentage of damaged cobs between these two types of maize were recorded in 2008-2009. This indicated that sweet maize was preferred by *O. nubilalis* to fodder maize (Table 2).

The study demonstrated that sorghum was the plant least infested and damaged by *O. nubilalis*. In the study years the caterpillars damaged from 3.0% (2010) to 16.2% (2008) of this species plants. Comparative analysis of the percentage of plants damaged by ECB for sweet maize, fodder maize and sorghum demonstrated that sorghum was statistically less frequently damaged by *O. nubilalis* caterpillars than both types of maize (Table 2).

Broken stems were an important type of damage caused by ECB in fodder maize and sorghum. This type of damage is also highly important for sweet maize, but mainly if plants are grown for seed.

In the study years most of this damage type was found on plots with sweet maize (34.7% to 66.7%), followed by fodder maize (29.7% to 52.5%). The lowest number of broken stems was found in sorghum fields, where only from 0.7% (2009) to 1.5% (2008) of plants were found to have such symptoms of pest feeding inside the stems. No statistically significant differences in the total percentage of broken stems between sweet maize and fodder maize were found. However, such differences were only recorded by comparing both maize types against sorghum (Table 2).

The percentage of stems broken below and above the cob was also compared for fodder maize and sweet maize. The highest number of stems broken below the cobs was found in sweet maize, where from 11.5% (2010) to 28.7% (2008) of plants were damaged. Also, the highest number of stems broken above the cobs was found in sweet maize, where from 23.2% (2010) to 40.5% (2009) of plants were damaged. However, statistical analysis demonstrated no significant differences between fodder maize and sweet maize for this type of damage.

Gnawing cobs at the base was an important type of damage caused by ECB caterpillars in maize cultivations. In the study years most of this damage type was found in sweet maize (5.5% to 13.2%), followed by fodder maize (2.2% to 6.2%). Statistically significant differences between sweet maize and fodder maize in the percentage of cobs gnawed at the base were only recorded in 2008 (Table 2).

Observations demonstrated significant differences between fodder maize and sweet maize, and sorghum in the number of tassels gnawed by caterpillars at the base. The highest number of plants with this type of damage was recorded for sweet maize (9.2% to 21.7%), followed by fodder maize (7.0% to 15.2%), while for sorghum only single plants (0.2% to 0.5%) had broken tassels due to gnawing by ECB caterpillars (Table 2).

The type of damage to maize and sorghum plants caused by ECB caterpillars largely depended on the number of pests. The highest number of caterpillars were found on sweet maize: in the study years on average from 0.8 (2010) to 1.5 (2008) individuals were feeding on a single cob, and on average from 2.0 (2010) to 4.4 (2008) inside the stem. A slightly lower number of caterpillars were found on fodder maize, where on average from 0.5 (2010) to 0.9 (2008) individuals were feeding on a single cob, and from 1.5 (2010) to 2.8 (2008) inside the stem. Inside the stems of sorghum plants on average 0.1 (2010) to 0.2 (2008) ECB caterpillars were found (Table 3).

Statistical analysis of the number of ECB caterpillars inside cobs demonstrated statistically significant differences between the two types of studied maize only in 2008. The analysis of the total number of caterpillars inside the stems demonstrated that in 2008–2009 there were statistically significant differences between sweet maize and fodder maize. In addition, significant differences in the number of caterpillars inside the stems were demonstrated for the entire analysed three-year period between the two types of maize and sorghum (Table 3).

Table 3. Mean number of caterpillars, holes and feeding tunnels in fodder maize, sweet corn and sweet sorghum plants in 2008-2010
Tabela 3. Średnia liczba gąsienic, otworów i kanałów żerowych w roślinach kukurydzy pastewnej, kukurydzy cukrowej i sorgo cukrowego w latach 2008-2010

Object Obiekt	Mean number of caterpillars, pcs. Średnia liczba gąsienic, szt.				Mean number of holes, pcs. Średnia liczba otworów, szt.				Mean number of feeding tunnels in plant, pcs. Średnia liczba kanałów żerowych, szt.		Mean length of feeding tunnels in plant Średnia długość kanałów żerowych w roślinie cm
		in stalk – w łodydze				in stalk – w łodydze					
	in cob w kolbie	above cob powyżej kolby	below cob poniżej kolby	total in stalk razem w łodydze	in cob w kolbie	above cob powyżej kolby	below cob poniżej kolby	total in stalk razem w łodydze	in cob w kolbie	in stalk w łodydze	
2008											
Fodder maize Kukurydza pastewna	0.9 a	2.2 a	0.6 a	2.8 a	0.6 a	2.6 a	0.7 a	3.3 a	0.4 a	1.8 a	17.6 a
Sweet corn Kukurydza cukrowa	1.5 b	2.9 a	1.5 b	4.4 b	0.9 a	3.7 b	1.8 b	5.5 b	0.7 a	3.2 b	25.8 a
Sweet sorghum Sorgo cukrowe	–	–	–	0.2 c	–	–	–	0.5 c	–	0.3 c	7.4 b
$LSD_{0.05}$ – $NIR_{0,05}$	sd – ri	ns – ni	sd – ri	sd – ri	ns – ni	sd – ri	sd – ri	sd – ri	ns – ni	sd – ri	sd – ri
2009											
Fodder maize Kukurydza pastewna	0.7 a	1.7 a	0.8 a	2.5 a	0.5 a	2.3 a	1.2 a	3.5 a	0.4 a	2.2 a	20.1 a
Sweet corn Kukurydza cukrowa	1.1 a	2.5 b	1.3 a	3.8 b	0.7 a	3.1 a	1.9 a	5.0 a	0.6 a	3.7 b	36.5 b
Sweet sorghum Sorgo cukrowe	–	–	–	0.2 c	–	–	–	0.3 b	–	0.2 c	8.2 c
$LSD_{0.05}$ – $NIR_{0,05}$	ns – ni	sd – ri	ns – ni	sd – ri	ns – ni	ns – ni	ns – ni	sd – ri	ns – ni	sd – ri	sd – ri
2010											
Fodder maize Kukurydza pastewna	0.5 a	1.1 a	0.4 a	1.5 a	0.3 a	1.7 a	0.7 a	2.4 a	0.2 a	1.9 a	13.7 a
Sweet corn Kukurydza cukrowa	0.8 a	1.6 a	0.6 a	2.2 a	0.5 a	2.3 a	1.0 a	3.3 a	0.5 a	2.6 a	21.2 a
Sweet sorghum Sorgo cukrowe	–	–	–	0.1 b	–	–	–	0.1 b	–	0.1 b	3.7 b
$LSD_{0.05}$ – $NIR_{0,05}$	ns – ni	ns – ni	ns – ni	sd – ri	ns – ni	ns – ni	ns – ni	sd – ri	ns – ni	sd – ri	sd – ri

explanations under Table 2 – objaśnienia pod tabelą 2

Detailed analysis of sweet maize plants and fodder maize plants also demonstrated statistically significant differences between the two types of maize with respect to the number of *O. nubilalis* caterpillars feeding inside the stems below the cobs, but only in 2008, and above the cobs in 2009 (Table 3).

The number of caterpillars was also correlated with the number of holes gnawed by them inside the stems and cobs, and the number of feeding tunnels and their length. The average number of holes gnawed in cobs per plant of fodder maize was from 0.3 (2010) to 0.6 (2008), and from 0.5 (2010) to 0.9 (2008) for sweet maize.

A much higher number of holes was gnawed by *O. nubilalis* caterpillars in the stems of plants of both types of maize. Sweet maize was the most susceptible for this type of damage, but statistically significant differences in the number of holes below and above the cobs between both types of studied maize were found only in 2008. In the study years the average number of holes gnawed below the cob per plant of fodder maize was from 1.7 (2010) to 2.6 (2008), and above the cob from 0.7 (2010) to 1.2 (2009). In sweet maize, the average number of holes inside the stem below the cob was from 2.3 (2010) to 3.7 (2008) and above the cob from 1.0 (2010) to 1.9 (2009). The comparison of the total number of holes in the stems of both types of maize and sorghum demonstrated a statistically lower number of holes in sorghum plants than in maize during the entire study period. The average number of holes in the stems of sorghum plants was from 0.1 (2010) to 0.5 (2008) (Table 3).

Observations demonstrated no significant differences between fodder maize and sweet maize with respect to the number of feeding tunnels in cobs. Their average number in fodder maize was from 0.2 (2010) to 0.4 (2008-2009), and from 0.5 (2010) to 0.7 (2008) for sweet maize. Clear differences in the number of feeding tunnels between the studied types of maize were found with respect to their number inside stems. The average number of feeding tunnels in stems of fodder maize was from 1.8 (2008) to 2.2 (2009), and from 2.6 (2008) to 3.7 (2009) for sweet maize. For sorghum, during the entire study period, the average number of feeding tunnels inside stems was statistically lower than in both types of maize, and ranged from 0.1 (2010) to 0.3 (2008) per plant.

The length of feeding tunnels was closely correlated with their number. The longest feeding tunnels were found in sweet maize and their average length in the study years was from 21.2cm (2010) to 36.5cm (2009). Slightly shorter feeding tunnels were found in fodder maize, i.e. from 13.7cm (2010) to 20.1cm (2009), and the shortest were found in sorghum, of average length from 3.7cm (2010) to 8.2cm (2009). Statistically significant differences between fodder maize and sweet maize in the length of feeding tunnels were only observed in 2009, and statistically the shortest feeding tunnels were found in sorghum during the entire study period, when compared to both types of maize (Table 3).

Polish publications provide extensive information on the harmfulness of the European corn borer to fodder maize and sweet maize, and authors indicate that this species is an important pest for both types of maize. This problem was studied on fodder maize by Kania and Sekuła [1960], Kania [1962a, b], Lisowicz [2004], Wałkowski and Bubniewicz [2004], Żołnierz and Hurej [2005], Bartos and Michalski [2006], Bereś [2007] and Sulewska and Ptaszyńska [2007], and on sweet maize by Waligóra *et al.* [2008] and others. These authors observed a diversified harmfulness of ECB caterpillars, with the highest rate in the southern part of Poland, where conditions are very favourable for the development of this pest species. The high harmfulness of *O. nubilalis* to fodder maize was observed near Wrocław as early as the 1950s, soon after this plant was introduced to farming in Poland [Kania 1962a, b]. As maize farming became more popular in Poland, the problem of the great harmfulness of the ECB was encountered in other parts of the country, particularly in the south-east, where caterpillars damaged over 90% of plants [Lisowicz 2003a]. Foreign authors have also reported ECB to be an important maize pest, e.g. in Hungary [Nagy 1964], Spain [Cordero *et al*. 1998], Bulgaria [Gerginov 1989], Germany [Welling 1989], Slovakia [Cagan 1998] and many other European countries. ECB was also brought accidentally to America, most likely from Hungary or Italy in the early 20th century, and it became an important maize pest there [Calvin *et al*. 1991]. ECB also causes damage to maize fields in Africa, e.g. in Egypt [Ismail 1989].

The great harmfulness of the European corn borer to fodder maize plants found in our own studies is in line with observations carried out in the same part of Poland by Lisowicz [2001, 2003a, b]. In addition, previous studies by Bereś [2010] on sweet maize demonstrated that *O. nubilalis* poses a significant risk to the commercial yield of this plant in south-eastern Poland near Rzeszów.

Fodder maize of the Wilga cultivar, which was used in this study, is one of the early-maturing cultivars registered in Poland. Candle cultivar sweet maize is also one of the early-maturing cultivars recommended for growing in Poland. Therefore, the great harmfulness of ECB caterpillars to both types of maize may be associated with the earliness of these plants, because studies by Bereś and Górski [2012] demonstrated that early-maturing maize cultivars are more susceptible to damage caused by *O. nubilalis*.

Other authors, e.g. Barry and Darrah [1991] attributed higher or lower resistance of maize plants to damage caused by ECB to 2-4-dihydroxy-7-methoxy-1,4-benzoxazin-3-one (DIMBOA) present in plant tissues, a compound determining temporary resistance of plants to the feeding pest. This compound attains the highest level in maize plants at the "leaf whorl stage", and decreases with plants development, making them more susceptible to ECB feeding. It can be anticipated that in the early-maturing maize cultivars used in our study, with more intense growth, the tissue level of DIMBOA was decreasing faster, and thus the plants were more prone to pest infestation. For example, Barry [1989] reported that young plants, not taller than 38 cm, are less susceptible to damage caused by *O. nubilalis.*

According to Lisowicz and Tekiela [2004] the greatest harmfulness of *O. nubilalis* caterpillars is associated with their feeding on cobs, in which they gnaw soft kernels, and in stems, where they can lead to breaking stems below cobs, especially if the whole plant turns down onto the ground. Kania and Sekuła [1960] emphasized that the type of damage caused by ECB and their impact on maize crop yield mainly depends on the number of caterpillars feeding inside plant tissues. Our studies confirmed that if the population size of ECB caterpillars is high, the frequency of economically-important types of damage, such as stems broken below the cob and the number of cobs with damaged kernels increases. The harmfulness of ECB caterpillars to maize and their effect on crop yield has been quite well investigated and described in the Polish literature. However, according to Godfrey *et al*. [1991] the high number of *O. nubilalis* caterpillars inside maize stems (over 3-5/plant) leads to a number of abnormalities in plant development, e.g. reduced photosynthesis, reduced stomal conductance, reduced intercellular CO_2 concentration, increased temperature of leaves, and disorders in water transport inside the plant.

The Polish literature provides no information about the harmfulness of ECB to sorghum. Only Kania [1961] listed sorghum as a plant which has been infested by the pest, but he did not report the rates of ECB damage to sorghum, or the types of damage caused by this pest. On the other hand Dicke *et al*. [1963] indicated that in North America ECB is considered an economically important sorghum pest.

Our study demonstrated that sorghum is not preferred by the European corn borer, which damaged not more than 16.2% of plants. Additionally, detailed analyses based on cutting plants lengthwise showed that there was a significantly lower number of ECB caterpillars in sorghum stems, and a lower number of gnawed holes and feeding tunnels than in fodder maize or sweet maize plants. It can be anticipated that the lower preference for sorghum by ECB in comparison to maize is potentially associated with sorghum resistance to feeding by ECB caterpillars. Dyatlova and Frolov [1999] reported that sorghum is in practice totally resistant to ECB feeding at the "leaf whorl stage". According to Guthrie *et al*. [1984, 1985], although the high natural resistance of sorghum to feeding by *O. nubilalis* reduces gradually up to the flowering stage (as in maize), it is still much higher after the end of flowering than that observed in maize, which in our study could have contributed to the lower damage rate of this plant caused by ECB caterpillars. A study by Guthrie et al. [1988] also demonstrated that, differently from maize, the resistance of sorghum to the European corn borer is not determined by the DIMBOA level in the plant, because this compound was not detected in tissues at all. Beck and Lilly [1949] claimed that the cyanogenetic content in whorl leaf tissue of sorghum plants is responsible, at least in part, for the high resistance of sorghum to *O. nubilalis* during the whorl stage of plant development.

CONCLUSIONS

1. In the study years the harmfulness of *Ostrinia nubilalis* to sweet maize and fodder maize was high. Caterpillars damaged 89.5 to 93.0% of plants and 53.5 to 76.0% of cobs in sweet maize, and 58.0 to 80.2% of plants and 29.5 to 42.2% of cobs in fodder maize.
2. A statistically significant lower rate of damage was found for sorghum plants than for both types of maize. The percentage of damaged sorghum plants in the study years ranged from 3.0 to 16.2%.
3. Sweet maize was most frequently damaged plant, and the highest rate of damage with impact on crop yield was recorded in this plant, which may suggest that this type of maize is particularly preferred by *O. nubilalis.* A very low damage rate to stems and tassels was found for sorghum plants.
4. A significantly higher number of caterpillars were found, as well as the number of holes and feeding tunnels gnawed by *O. nubilalis*, in sweet maize and fodder maize plants than in sorghum.
5. The study demonstrated that of the three analyzed feeding plants for *O. nubilalis*, the highest risk was posed by the pest to sweet maize and fodder maize, in which it would require control. In sorghum, the pest usually damaged single plants, and the posed risk was too low to justify pest control using intervention-based plant protection methods.

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USZKODZENIA POWODOWANE PRZEZ *Ostrinia nubilalis* HBN. NA KUKURYDZY PASTEWNEJ (*Zea mays* L.), KUKURYDZY CUKROWEJ (*Zea mays* VAR. *saccharata* (STURTEV.) L.H. BAILEY) ORAZ SORGO CUKROWEGO (*Sorghum bicolor* (L.) MOENCH) W OKOLICACH RZESZOWA (POŁUDNIOWO-WSCHODNIA POLSKA) W LATACH 2008-2010

Streszczenie. Badaniami objęto wybrane rośliny żywicielskie dla omacnicy prosowianki (*Ostrinia nubilalis* Hbn.): kukurydzę pastewną odmiany Wilga, kukurydzę cukrową odmiany Candle oraz sorgo cukrowe odmiany Sucrosorgo 506. Obserwacje nad rodzajem uszkodzeń roślin powodowanych przez gąsienice wykonano w latach 2008-2010 w południowo-wschodniej Polsce w Terliczce koło Rzeszowa (50°06' N; 22°05' E). W latach badań szkodliwość *O. nubilalis* była zróżnicowana, na co duży wpływ miały warunki meteorologiczne oraz gatunek rośliny objętej badaniami. Najwyższą szkodliwość gąsienic ECB w analizowanym trzyleciu odnotowano dla kukurydzy cukrowej; uszkodziły one od 89,5 do 93,0% roślin oraz od 53,5 do 76,0% kolb. Mniejszą szkodliwość omacnicy prosowianki stwierdzono na kukurydzy pastewnej; gąsienice uszkodziły od 58,0 do 80,2% roślin oraz od 29,5 do 42,2% kolb. Najmniej zasiedlanym i uszkadzanym przez *O. nubilalis* gatunkiem było sorgo, u którego gąsienice uszkodziły od 3,0 do 16,2% roślin. Spośród analizowanych uszkodzeń roślin najpowszechniej spotykanymi były złomy łodyg. Najwięcej tego typu uszkodzeń stwierdzono u kukurydzy cukrowej (od 34,7 do 66,7%), nieznacznie mniej u kukurydzy pastewnej (od 29,7 do 52,5%), natomiast tylko sporadycznie u sorgo (od 0,7 do 1,5%). Rodzaj uszkodzeń roślin kukurydzy oraz sorgo powodowanych przez gąsienice ECB zależał w dużej mierze od ich liczebności. Najwięcej gąsienic stwierdzano w roślinach kukurydzy cukrowej, natomiast tylko pojedyncze osobniki występowały w roślinach sorgo

Słowa kluczowe: kukurydza, omacnica prosowianka**,** rośliny żywicielskie, sorgo, szkodliwość

Accepted for print – Zaakceptowano do druku: 13.08.2012