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Evaluation of damage and control of cream-bordered green pea (*Earias chlorana* Hübner) caterpillars in a 4-year old plantation of common willow (*Salix viminalis* L.)

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Abstract

The aim of the current study was to assess the degree of damage caused by the cream-bordered green pea (*Earias chlorana* Hübner), belonging to the family *Noctuidae*, as well as evaluate the potential control of this pest in a 4-year old plantation of common willow (*Salix viminalis* L.). Analyses were conducted in the years 2010 and 2011 at the Research and Education Centre Gorzyń, Złotniki Branch, Poznań University of Life Sciences. The occurrence of cream-bordered green pea on clone 1100 of common willow (*Salix viminalis* L.) was evaluated in two unifactorial experiments. The aim of the first experiment was to assess the residual effect of sewage sludge applied in the year of plantation establishment, while the second experiment analysed the effect of insecticide applications. Analysis of variance did not show any significant residual effect of sewage sludge on the proportion of shoots damaged by the pest, while the application of chemicals significantly limited the volume of damage caused by cream-bordered green pea caterpillars. In both 2010 and 2011, the greatest efficacy in the reduction of the damaged shoots by the cream-bordered green pea (87.2% and 87.8%, respectively) was obtained after the application of esfenvalerate. The highest yield increment in comparison to the control was recorded in 2010 (6.9 t ha^{-1}, 32.7%).

Key words: *Earias chlorana*, insecticide application, *Salix viminalis*, sewage sludge.

Introduction

The greatest share in the production of renewable fuel sources is connected with biomass (98.05%), whose use for energy purposes in accordance with the Strategy for the Development of Renewable Energy Sector (2002) has been increasing from year to year. Agriculture as the main producer of biomass has to meet the requirements imposed by the European Union (Directive 2001/77/EC, 2003; Dreszer et al., 2003).

Plantations of common willow in Poland have been popular for a long time (Ropek, 2007) and common willow chips are important items in the balance of renewable energy sources for heating purposes (Szczukowski et al., 2004). The risk of failure in growing this crop is initially small and it is most frequently connected with adverse weather conditions in the first year and weed infestation in the established plantation (Energy crops, 2003). As the area of permanent crop plantations has been increasing, a rapid and uncontrolled spread of diseases and pests has become a considerable problem (Mrówczyński et al., 2007; Pruszyński, 2009; Remlein-Starosta, Nijak, 2010). Protection is hindered not only by insufficient knowledge on various pests constituting a potential threat, but also a lack of agents admissible for use in plantations of energy crops to be used for heating purposes (Matyjaszczyk et al., 2008; Pruszyński, 2009; Dłużniewska, 2011). Common willow provides a living environment for many insect species (Sage, 1998), mostly posing a threat to this crop. An example of such a phytophage, found with increasing frequency in plantations of common willow, is the cream-bordered green pea (*Earias chlorana* Hübner) – a butterfly belonging to the family *Noctuidae*. It is considered to be one of the most dangerous agrophages occurring in nurseries of common willow (Czerniakowski, 2005). Damage is caused by the caterpillar stage, while the imago is an inconspicuous butterfly of up to 20 mm, whose forewings are pea green and hindwings are white. Caterpillars of 15 mm in size are light brown with a characteristic white stripe repeatedly narrowing along the back (Łabanowski, Soika, 2003).

Damage caused by this pest consists in a strong deformation of shoots. The deformations occur in the apical parts of shoots as a result of caterpillars feeding inside leaves folded together. Caterpillars feed on young leaves; damage the shoot apex, thus inhibiting proper plant development. With shoot growth, the damaged apex bends considerably and new shoots develop from lateral buds located below, causing the so-called witches'

broom. This may pose a serious threat to plantations of common willow, reducing shoot growth increments by 30–50% and thus decreasing the expected yield of biomass (Czerniakowski, 2005). In recent years, the number of reports on damage caused by the cream-bordered green pea has been increasing (Noreika, Smaliukas, 2005; Mrówczyński et al., 2007; Nijak, 2009; Remlein-Starosta, Nijak, 2010). Thus it seems important to search for effective protection methods against this pest in common willow plantations.

The aim of the present study was to assess the intensity of incidence of the cream-bordered green pea on a 4-year old plantation of common willow (*Salix viminalis* L.), carried out in the central Wielkopolska region, and to identify potential methods of its chemical control.

Materials and methods

In the years 2010 and 2011, studies were conducted on a 4-year old clone 1100 of common willow (*Salix viminalis* L.), coming from the University of Warmia and Mazury in Olsztyn. The coppice plantation was run in the cycle of annual harvest and it was located in Złotniki on the fields of the Research and Education Centre Gorzyń, Poznań University of Life Sciences. The injury of the cream-bordered green pea was assessed in two unifactorial experiments. The experiments were established in a random block design in four replications. The treatment in the first experiment comprised the dose of sewage sludge applied in the year of plantation establishment with the following levels of the experimental factor: the control, fertilization with sewage sludge (dose of 10 t ha^{-1} DM). Sewage sludge came from the sewage treatment plant in Szamotuły and the dosage was established in accordance with the then binding Ordinance of the Minister of the Environmental Protection (2002). The second experimental factor was the insecticide application: the control, active substance (a.s.) chlorpyriphos + cypermethrin at a dose of 0.6 l ha^{-1}, a.s. esfenvalerate at a dose of 0.4 l ha^{-1}, a.s. dimethoate at a dose of 0.5 l ha^{-1}, respectively. The chemicals were sprayed using a mounted trailer sprayer at a working pressure of 2 MPa and a spray volume of 600 l ha^{-1}. Observations of damage caused by caterpillars were conducted on each plot in both experiments on 25 successive shrubs. In order to identify the pest, caterpillars were collected from folded leaves of common willow and were kept until pupation in accordance with the methodology recommended by OEPP/EPPO (2002). Characteristics of imagines confirmed the earlier diagnoses proposed using keys by Boczek (1996) and Łabanowski and Soika (2003). In the experiment evaluating the efficacy of selected insecticides the assessment of plant damage was conducted twice, i.e. before spraying in June and 14 days after the application, in July. The efficacy of the preparations used was calculated according to the formula by Abott (1925). After harvest, performed after the fall of all leaves (December), the yield of shoot fresh matter of common willow was calculated. Results were subjected to the analysis of variance at the confidence level $\alpha = 0.05$. The weather conditions were very different in each of the experimental years and the course of changes is presented using Walter's (1976) climate diagrams (Fig.).

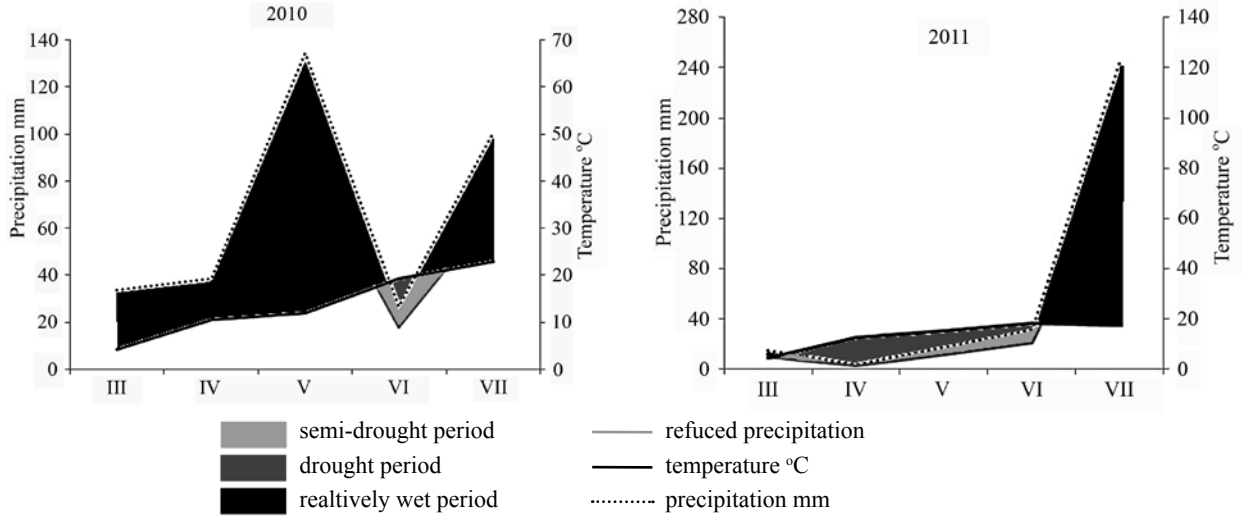

Figure. Climate diagrams characterising weather conditions in 2010 and 2011, prepared according to Walter (1976)

Results and discussion

In both experiments and years the pest was found on clone 1100 of common willow.

Results of the experiment evaluating the efficacy of chemical control of this pest confirm its high feeding intensity particularly in 2010, when as many as 49.1% shoots were damaged (Table 1). In turn, in 2011 less damage was observed and the proportion of damaged shoots amounted to 22.4%. Similar results were also recorded in a study by Remlein-Starosta and Nijak (2010), conducted in 2009, when 32.5% of shoots were damaged. It may be assumed that in 2010 the development of the pest was promoted by the frosty and snowy winter, similarly to the development of dart moths belonging to the same family of *Noctuidae*, as it was reported by Mrówczyński

et al. (2005). Moreover, it may be concluded from a study by Jakubowska (2011), conducted in 2003–2006 in three locations in two provinces of Poland, on the qualitative structure of the *Noctuidae* populations (*Noctuidae*, *Lepidoptera*) in selected agricultural landscape habitats that the mass gradation of various species of this family was observed in the area of Poznań (the Wielkopolskie province) and Więcławice (the Kujawsko-Pomorskie province). The author was of an opinion that their occurrence depended on the natural environment and was most probably related with habitat moisture levels. The year 2010 was characterised by greater humidity (higher precipitation levels) than 2011, thus the results recorded within this study confirm the assumptions presented by Jakubowska (2011). Moreover, an extreme drought, lasting for almost three months of the vegetation season in 2011, could have limited the development of the pest and reduced the population size.

Table 1. Number and percentage of shoots damaged by cream-bordered green pea in 2010–2011 prior to the insecticide application

Parameter	Year	
	2010	2011
Number of damaged shoots per plant	5.2	4.0
$LSD_{0.05}$	n.s.	
% damaged shoots	49.1	22.4
$LSD_{0.05}$	15.08	

n.s. – not significant difference

Each of the active agents used in the experiment on insecticide applications caused a reduction in the number and percentage of damaged shoots of common willow (Table 2). The experimental plots differed in the number, but also the percentage of plants damaged by the cream-bordered green pea, thus the efficacy of the tested insecticides was evaluated using the formula proposed by Abott (1925). The efficacy of the tested preparations was calculated for each plot by comparing the number of damaged shoots after the spraying to the number of damaged shoots prior to the spray application. Both in 2010 and 2011, the greatest efficacy in the reduction of the larval population size of the cream-bordered green pea (87.2% and 87.8%, respectively) was obtained after the application of esfenvalerate (Table 3). However, the indicated efficacy of this insecticide did not differ significantly from that recorded after the application of a chlorpyriphos + cypermethrin mixture. Significantly the lowest efficacy was recorded for dimethoate. Similar results on the protection of common willow were obtained by Remlein-Starosta and Nijak (2010), who also pointed to chlorpyriphos and esfenvalerate as substances highly effectively reducing damage caused by the cream-bordered green pea. In the control plot, where no chemicals were applied on plants, shoots dried in their apical part or showed stunted growth. As a consequence, this may lead to a deteriorated quality of breeding material, first of all a reduced number of scions. The cream-bordered green pea, as studies suggest (Czerniakowski, 2005), particularly willingly infests young common willow plants. Since scions are collected from young offshoots (1- to 2-year old), it is the plantations producing propagation material that need to be particularly protected.

Table 2. The number and proportion of damaged shoots of common willow before and after insecticide application

Observations		Active ingredients of insecticide			$LSD_{0.05}$
		chlorpyriphos + cypermethrin	esfenvalerate	dimethoate	
Number of damaged shoots per plant					
Before spraying	2010	7.0	5.8	1.8	2.44
	2011	3.2	4.3	3.9	n.s.
Mean		5.1	5.0	2.9	1.18
After spraying	2010	2.1	0.8	1.1	1.00
	2011	0.6	0.5	1.2	0.44
Mean		1.34	0.62	1.13	0.48
% damaged shoots					
Before spraying	2010	68.3	62.6	16.3	22.5
	2011	17.8	24.8	20.5	6.42
Mean		43.1	43.7	18.4	10.43
After spraying	2010	13.6	4.0	5.8	7.55
	2011	2.3	6.4	3.1	2.92
Mean		7.9	5.2	4.5	3.60

n.s. – not significant difference

Table 3. Efficacy of insecticides against cream-bordered green pea on common willow

Active ingredient	Application efficacy % according to Abott (1925)		Mean
	2010	2011	
Chlorpyriphos + cypermethrin	70.0	82.6	76.3
Esfenvalerate	87.2	87.8	87.5
Dimethoate	35.3	70.2	52.7
$LSD_{0.05}$	32.25	13.19	14.47

When analysing the harvested yields of common willow we may observe their variability in the years of the study (Table 4). The wet year of 2010 turned out to be more advantageous for growth of common willow, as the mean yield of harvested shoots was 24.6 t ha^{-1}. The insecticide applications increased the yield of rods in comparison to the unprotected treatment and the recorded difference was significant in 2010 and non-significant in 2011. In both years of the study the highest yield of rod fresh weight was obtained when protecting common willow plants using a preparation containing esfenvalerate as the active ingredient. Yield increment in comparison to the control was 6.9 t ha^{-1} (32.7%) in 2010 and 3.3 t ha^{-1} (16.9%) in 2011. Good yielding of plants after the application of this insecticide resulted from its high efficacy in the control of cream-bordered green pea larvae.

In the experiment evaluating the residual effect of fertilization applied before common willow planting, no significant differences were observed in the percentage

Table 4. Yields of common willow as influenced by insecticide application

Treatment	2010	2011	Mean	Difference in relation to the control				Mean	
				2010		2011			
				t ha^{-1}	%	t ha^{-1}	%	t ha^{-1}	%
Control	21.1	19.5	20.3						
Chlorpyriphos + cypermethrin	24.9	21.7	23.3	3.8	18.0	2.2	11.3	3.0	14.8
Esfenvalerate	28.0	22.8	25.4	6.9	32.7	3.3	16.9	5.1	25.1
Dimethoate	24.3	21.5	22.9	3.2	15.2	2.0	10.3	2.6	12.8
$LSD_{0.05}$	1.88	n.s.	1.80						
Mean	24.6	21.4							

n.s. – not significant difference

of damaged shoots compared at identical applied doses or the type of fertilizer (Table 5). Similarly, in a study by Sulewska et al. (2010) the application of sewage sludge in maize growing had no significant effect on the number of plants damaged by another pest, the European corn borer (*Ostrinia nubilalis* Hbn.), a butterfly whose caterpillars feed inside stems.

Table 5. The residual effect of fertilization on the number of shoots damaged by caterpillars of cream-bordered green pea

Treatment	Damaged shoots %		Mean
	2010	2011	
I – control (0)	11.03	21.97	16.50
II – sewage sludge (10 t ha^{-1} DM)	11.58	22.72	17.15
$LSD_{0.05}$	n.s.	n.s.	n.s.

n.s. – not significant difference

Pruszyński (2009) warned about a reduction in the number of agents admissible in protection of common willow for energy purposes as a result of pesticide producers' lack of interest. This situation concerns not only common willow, but also other energy crops. Each crop monoculture becomes an environment promoting infestation by various insects, including pests. With the increasing area of energy crop plantations and a lack of protection programmes, this problem is going to become increasingly serious. Thus it seems significant to conduct further studies on various insects infesting plantations of common willow, including testing of insecticides so that the recorded results may constitute the basis for the establishment of protection programmes for common willow as an energy crop.

Conclusions

1. Higher precipitation levels in the vegetation season indicate the tendency for higher damage caused by cream-bordered green pea on common willow.

2. The application of insecticides reduced the number and proportion of shoots damaged by caterpillars of cream-bordered green pea. Esfenvalerate was the most effective substance in this respect. Its efficacy was the highest in both years (87.2% in 2010 and 87.8% in 2011).

3. Fertilization with sewage sludge before the establishment of the plantation did not cause the residual effect on the proportion of shoots damaged by this pest.

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Gluosninio žalsvinuko (*Earias chlorana* Hübner) vikšrų daromos žalos ir apsaugos nuo šio kenkėjo tyrimai ketverių metų amžiaus paprastojo gluosnio (*Salix viminalis* L.) plantacijoje

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Santrauka

Tyrimo tikslas – nustatyti žalos, daromos gluosninio žalsvinuko (*Earias chlorana* Hübner), priklausančio *Noctuidae* šeimai, intensyvumą ir įvertinti šio kenkėjo kontrolės galimybę ketverių metų amžiaus paprastojo gluosnio (*Salix viminalis* L.) plantacijoje. Tyrimai atlikti 2010 ir 2011 m. Poznanės gyvybės mokslų universiteto Gorzyń tyrimų ir mokymo centro Złotniki filiale. Gluosninio žalsvinuko paplitimas ant paprastojo gluosnio klono 1100 vertintas dviejų vieno veiksnio bandymų metu. Pirmojo bandymo tikslas – įvertinti nuotekų dumblo, paskleisto plantacijos įrengimo metais, liekamąjį poveikį. Antrojo bandymo metu tirtas insekticidų naudojimo efektyvumas. Dispersinė analizė neparodė nuotekų dumblo esminio liekamojo poveikio kenkėjo pažeistų ūglių kiekiui, o insekticidai esmingai sumažino gluosninio žalsvinuko vikšrų daromą žalą. Ir 2010, ir 2011 m. gluosninio žalsvinuko pažeistų ūglių kiekį efektyviausiai (87,2 ir 87,8 %) sumažino insekticidas esfenvaleratas. Palyginus su kontroliniu variantu, didžiausias derliaus priedas buvo gautas 2010 m. – 6,9 t ha^{-1}, arba 32,7 %.

Reikšminiai žodžiai: *Earias chlorana*, insekticidų naudojimas, nuotekų dumblas, *Salix viminalis*.