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The Influence of Synthetic Insecticides on the Dynamics of Cabbage Stem Weevil (*Ceutorhynchus pallidactylus* Marsh.) and Cabbage Pod Weevil (*Ceutorhynchus obstrictus* Marsh.) in Winter Oilseed Rape

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Abstract. Oilseed rape is affected by a complex of different crucifer pests. Cruciferous stem weevils (*Ceuthorhynchus* spp.) are relatively new oilseed rape (*Brassica napus* L.) pests in Latvia. Although currently brassica pest control is performed according to the appearance of first specimens of *Ceutorhynchus* or other brassica pests, for a large number of insecticide treatments a positive biological efficiency is observed (however, within a large range – 8–98%). The current application of brassica pest control may be described as preventive, which is not permitted in the integrated pest management system. The present research estimates biological efficiency and application time of synthetic pyrethroid (PIR) and combined pyrethroid+neonicotonoid (PIR+NNI) to control winter oilseed rape pest species, as well as stimulates discussion about their use. Evaluation of the monitoring data of *Ceutorhynchus* spp. showed that *C. typhae* and *C. sulcicollis* emerge first, but damaging species *C. pallidactylus* – a week later. Consequently it is not only necessary to monitor the weevils but also to identify their species in order to decide on the control measures. The combined PIR+NNI insecticide proved to have the highest biological efficiency for cabbage stem weevil control. Both classes of synthetic insecticides revealed a considerable biological efficiency for weevil control. The research suggests that effectiveness of insecticide is affected by many factors: plant development stage during the spray, agro-climatic conditions, spray quality, field location and size, distribution of pests, and crop rotation.
Key words: *Ceutorhynchus* spp., winter oilseed rape, control, insecticides.

Introduction

Spraying of synthetic insecticides, carried out several times during plant vegetation (Richardson, 2008), is a method still widely used for brassica pest control in many European countries. The same method is used also in Latvia.

During the survey of four farms involved in the present study, it was found that brassica pests are being controlled according to the warnings received from advisors (personal communication with farmers). However, as distribution of insects is greatly influenced by the field location and cropping technology, insect limitation can be characterized as preventive, which is not recommended in integrated pest management.

One of the reasons for greater distribution of brassica pests mentioned in the literature is decrease in sensitivity to the synthetic pyrethroid, especially for pollen beetle and – in some European countries – also for cabbage stem and pod weevil. Therefore, during the growing season, as the numbers of brassica pest specimens reach the pre-control level, more frequent sprays are necessary (Thieme, Heimbach, & Müller, 2010). In our research, spraying was performed twice in a season (in many European countries – on average 1–4 times).

Control of brassica pests should be carried out only when population size exceeds the economic threshold; however, in order to determine this, it is necessary to calculate the economic damage threshold (Higley & Pedigo, 1993). The economic damage threshold is calculated by taking into account the yield loss caused by particular pest species, calculated in monetary terms, and compared to the costs of spraying.

Both indicators differ in European countries, as they are influenced by rapeseed purchase prices, climatic conditions, cultivation technologies, and other factors (Garbe, Gladders, & Lane, 2000). But with the increasing brassica pest resistance

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to pyrethroids, the economic threshold evaluation should include variety evaluation, plant development stages during the damage, oilseed rape plant yield compensation characteristics, as well as environmental factors – pesticide impact on the soil, groundwater and parasitoids (Zlof, 2008; Poston, Pedigo, & Welch, 1983).

Two synthetic insecticide classes are represented in the National Register of Plant Protection Products for control of brassica pests in Latvia – synthetic pyrethroids (PIR) and neonicotonoids (NNI). PIR-class insecticides are cheaper, with a wider product range, therefore their use is more common. Two PIR-class insecticides were used in our study for control of brassica pests – Decis Mega (deltamethrin 50 g L^{-1}), (0.15 L ha^{-1}), and Fastac (alfa-cypermethrin 83 g L^{-1}), (0.25 L ha^{-1}). PIR insecticides have contact effect, therefore brassica pest control should be done during the emergence of the imago, but prior to the egg laying (Evans, 2007).

Proteus OD (thiacloprid 100 g L^{-1}, deltamethrin 10 g L^{-1}), which is a combined pyrethroid+ neonicotonoid (PIR+NNI) insecticide, has become increasingly popular among the farmers; its usage dose is 0.75 L ha^{-1}. This product has systemic and contact effect, meaning that deltamethrin limits the imago during the spraying but thiacloprid – hatched larvae in stems, flower buds and pods. Thiacloprid is an active substance with systemic effect; it is taken up by the plant through the leaf surface and then moves translaminary in the direction of growth. This active substance has a strong contact as well as gastrointestinal effects; it acts on the receptors of the pest and is different than pyrethroids[1].

The aim of the present paper is to evaluate biological efficiency and application timing of PIR and PIR+NNI insecticides for brassica weevil controlin winter oilseed rape sowings. The results will help improve the control measures of *Ceutorhynchus* spp. in the integrated pest management system.

Materials and Methods

The research was done in four conventional winter oilseed rape farms in 12 sowings, each 34–59 ha large, located in Central Latvia, from the year 2009 to 2011.

None of the winter oilseed rape sowings involved in the study was consecutive; all were sown with at least two-year interval in the same field. Line variety 'Catalina' and hybrids 'Excalibur' F_1 and 'Visby' F_1, which do not deter insects and are not resistant to them, were sown.

Monitoring of *Ceutorhynchus pallidactylus* Marsh., syn. *C. quadridens* Pan., and *Ceutorhynchus obstrictus* Marsh., syn. *C. assimilis* Payk., was done by using 10 yellow Moerike water traps (MWT) in each sowing. MWT were placed systemically randomized 20 and 50 m from the edges of the fields. A 24-m horizontal gap between the traps matched the technological tracks. Imagos were recorded and collected once a week, starting with spring when the average daily temperature reached +5 °C until the seed ripening phase (BBCH 70–80 according to Meier, 2001).

Each year one of four brassica pest control schemes was used:

1) two applications of Decis Mega 50 g L^{-1} (deltamethrin 50 g L^{-1}) 0.15 L ha^{-1};
2) Proteus 110 OD s.k. (thiacloprid 100 g L^{-1}, deltamethrin 10 g L^{-1}) 0.75 L ha^{-1}, and Fastac 50 e.k. (alfa-cypermethrin 83 g L^{-1}) 0.25 L ha^{-1} (in 2011, pest control was done once using Fastac);
3) two applications of Proteus 110 OD s.k. 0.75 L ha^{-1};
4) insecticide treatment was not performed.

According to the experience of oilseed rape growers and recommendations of advisors, insecticide spraying was carried out either as prevention or when brassica pests were found.

The first application (T1) was done at flower bud development stage (BBCH 51–55) of winter oilseed rape, second application (T2) – during flowering (BBCH 59–62).

Efficiency of insecticide application is calculated by using modified Abbot's formula (1) for controlling brassica stem and pod weevil *(Ceutorhynchus* spp.):

$$BE\% = \frac{(A-B)}{A} \times 100, \quad (1)$$

where

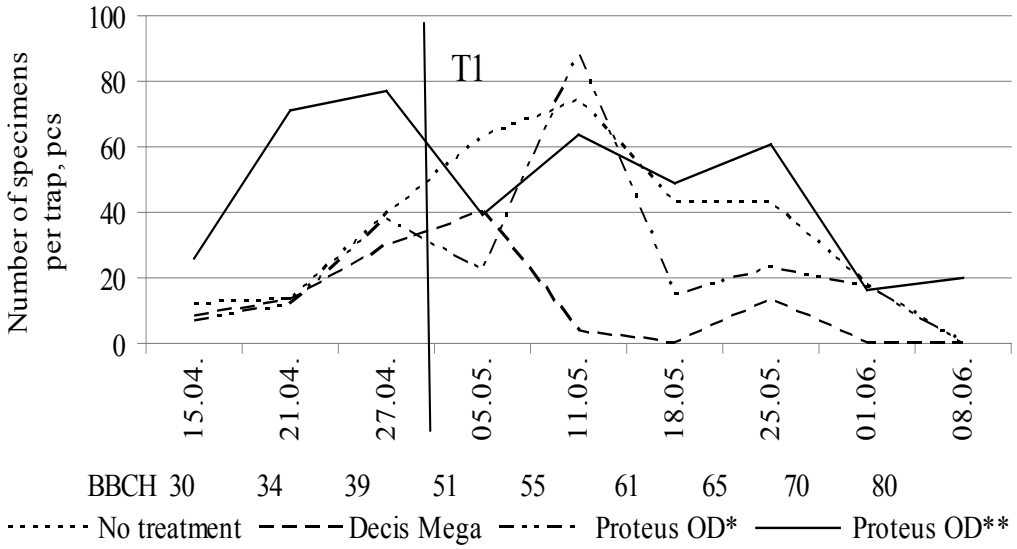
A – number of specimens before application of insecticide, pcs;

B – number of specimens seven days after application of insecticide, pcs.

Results and Discussion

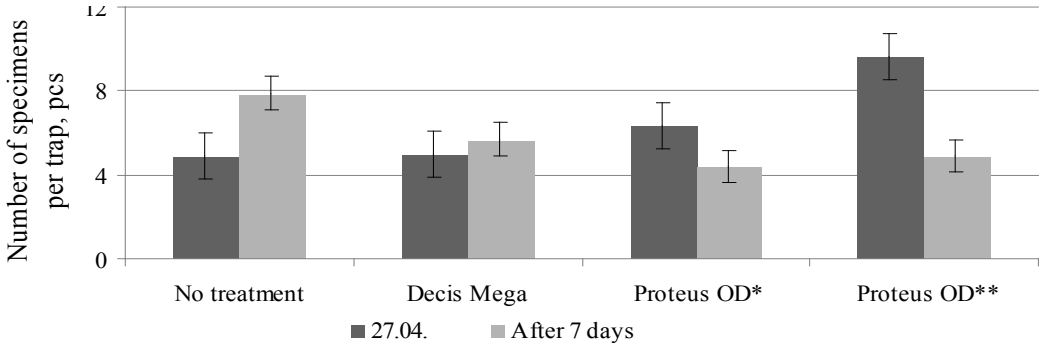
In the year 2009, research results showed that the number of cabbage stem weevil specimens in

[1] Retrieved March 2012 from http://www.bayercropscience.lv/files/mark/Proteus%20-label-vers%202.pdf



*, ** – in different sowings
T1 – first treatment

Fig. 1. The dynamics of *C.pallidactylus* specimens in different sowings using synthetic insecticides (T1) and without insecticide application, the year 2009.



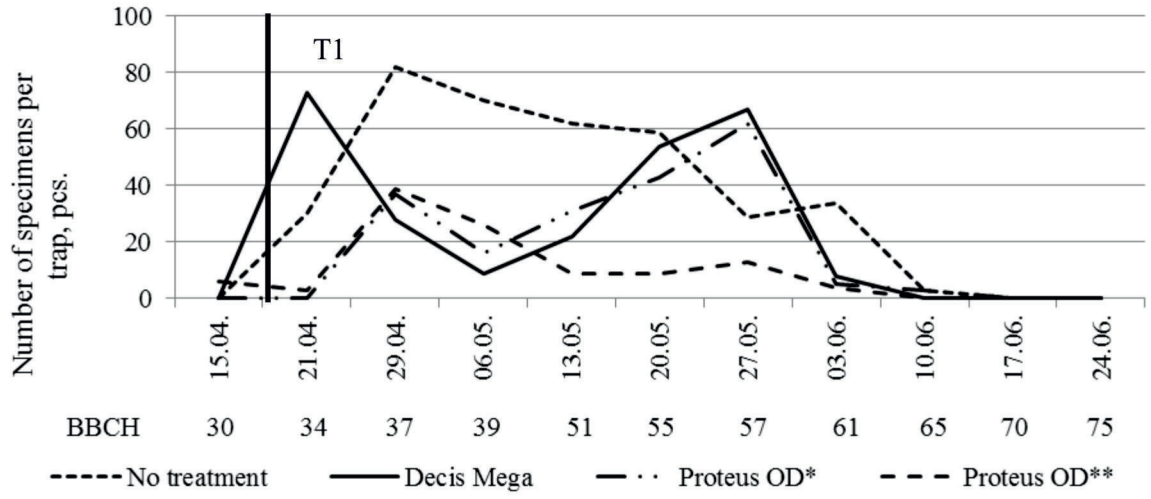
*, ** – in different sowings

Fig. 2. The average number of *C.pallidactylus* specimens per trap (0.03 m^2) in different sowings with and without first insecticide treatment, on April 27 and seven days later, the year 2009.

sowings where PIR+NNI products were applied had decreased (Fig. 1), whereas in sowings where PIR products were used or no insecticides were applied, the number of specimens continued to increase. The question on the low efficiency of PIR remains unanswered; possibly this may be linked to the fact that specimens continued to emerge from the overwintering sites.

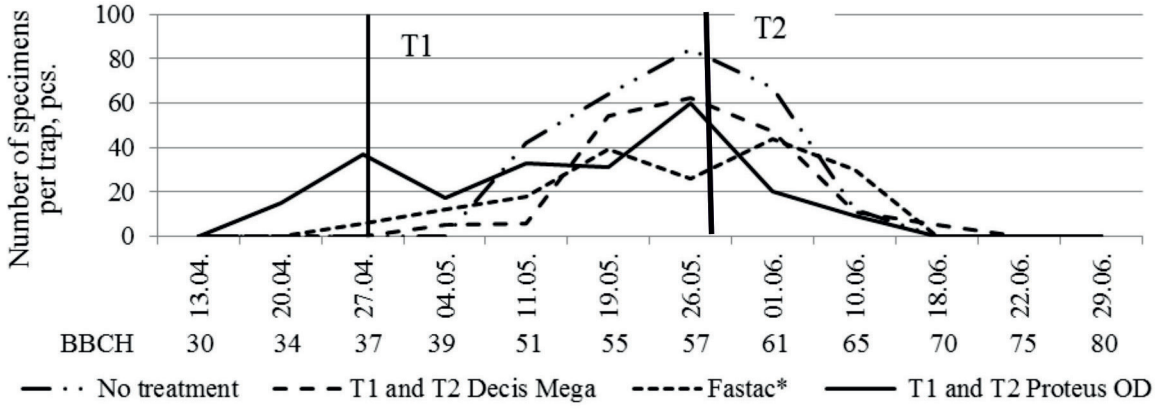
The highest biological efficiency (49% and 30%) of insecticides on cabbage stem weevil (*C. pallidactylus*) was observed in sowings where T1 with PIR+NNI (treatments in two different oilseed rape sowings) was performed (Fig. 2). The different results obtained while using the same pesticide may indicate the influence of the spray quality and field location on the insecticide efficiency. Agro-climatic weather effects were ruled out when the average daily air temperature on the spraying days was +12±2 ºC and no rainfall. Polish scientists claim that efficiency of PIR reaches 40% on the fourth day after spraying and decreases by 4% after seven days, but for PIR+NNI – by only about 1.42% (Węgorec & Zamoyska, 2007).

Analysis of data obtained during cabbage stem weevil monitoring in 2010 revealed that T1 had been performed early in spring with the emergence of first cabbage stem weevil (*C. pallidactylus*) specimens (Fig. 3). In the sowing where control was done with



*, ** – in different sowings
T1 – first treatment

Fig. 3. The dynamics of *C.pallidactylus* specimens in different sowings using synthetic insecticides (T1) and without insecticide application, the year 2010.



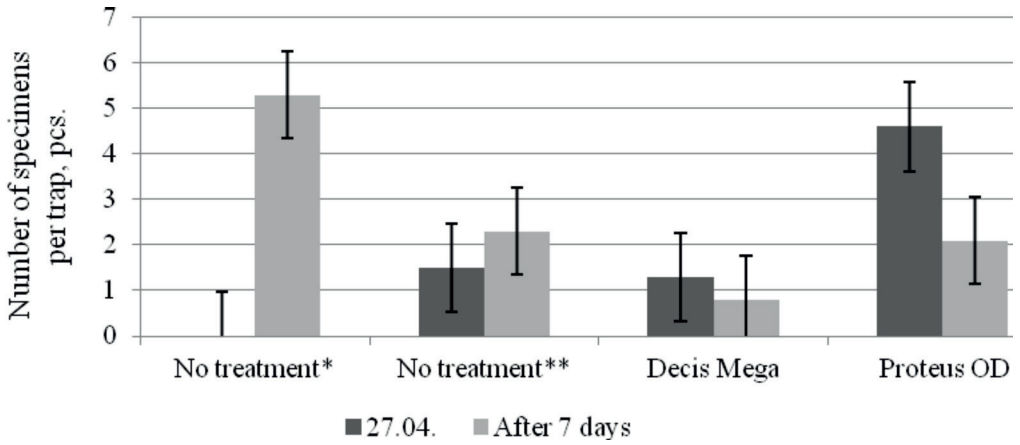
* – treatment with Fastac was done on April 30
T1 – first treatment
T2 – second treatment

Fig. 4. The dynamics of *C.pallidactylus* specimens in different sowings using synthetic insecticides (T1 and T2) and without insecticide application, the year 2011.

PIR (Decis Mega), biological efficiency of insecticide proved to be negative. A positive biological efficiency was observed for PIR+NNI (50%), but only in one of the two separate sowings. During insecticide treatment, average daily temperature reached +14±3 ºC and no precipitation. In sowings where no control measures were performed, new specimens emerged from wintering sites and their numbers continued to increase.

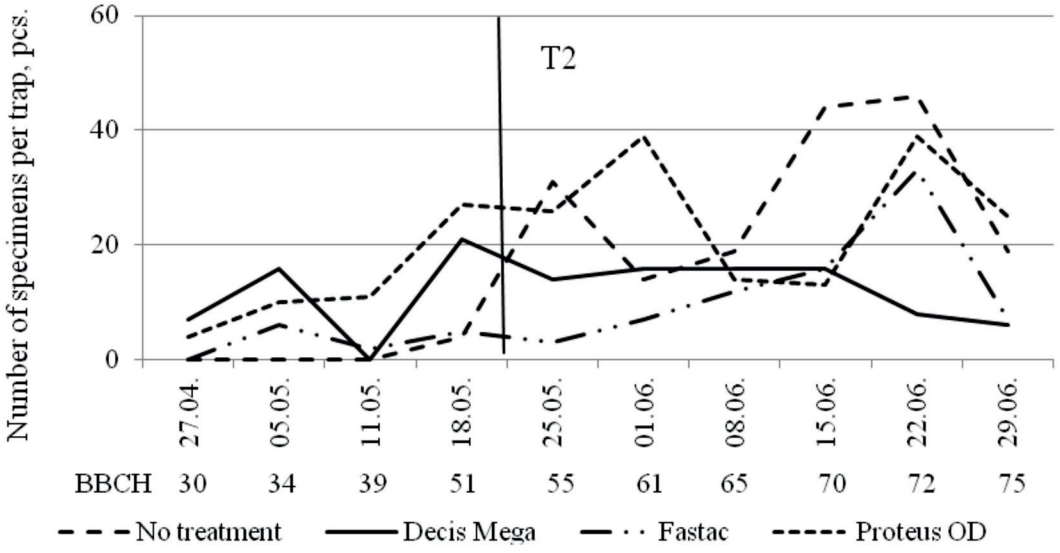
In the year 2011, emergence of cabbage stem weevil specimens was influenced by the field location and size since the spring was late and the ground was covered by a thick snow layer. Weevil emergence was observed only in one sowing where PIR+NNI was used – its biological efficiency was 54%, therefore insecticide treatment was necessary; in one of the sowings emergence was observed later (Fig. 4).

The monitoring data suggest that second insecticide spraying (T2) had a greater impact on the specimens of a particular species compared to first application, but specimens of *C. pallidactylus*, emerging at the beginning of flowering, could not cause significant damage to oilseed rape plants (Fig. 5).



*, ** – in different sowings

Fig. 5. The average number of *C.pallidactylus* specimens per trap (0.03 m^2) in different sowings with and without first insecticide treatment, on April 27 and seven days later, the year 2011.



T2 – second treatment

Fig. 6. The dynamics of *C.obstrictus* specimens in different sowings using synthetic insecticides (T2) and without insecticide application, the year 2009.

European scientists recommend using single spraying to limit all *Ceutorhynchus* spp. species, and it should be carried out when 10 weevils are observed in traps. In regions where *C. pallidactylus* is observed, the control should be done by using PIR insecticides two to three weeks after first specimens have been observed in traps (Alford, 2003).

The monitoring data of *Ceutorhynchus* spp. obtained during our study demonstrated that less destructive species *C. typhae* and *C. sulcicollis* emerge first, but cabbage stem weevil (*C. pallidactylus*), whose females lay eggs approximately two weeks after their emergence, – a week later.

Our observations suggest that it is necessary not only to monitor the weevils but also to identify their species in order to decide on the control of pests. Proteus OD, the combined PIR+NNI insecticide, has been recognized as having the highest biological efficiency for cabbage stem weevil control.

There are research findings that control of cabbage seed weevil by pyrethroid insecticides should be done from the start until middle of flowering (Ballanger, Détourné, Delorme, & Pinochet, 2007).

In the year 2009, emergence of the first cabbage seed weevil in all sowings was observed

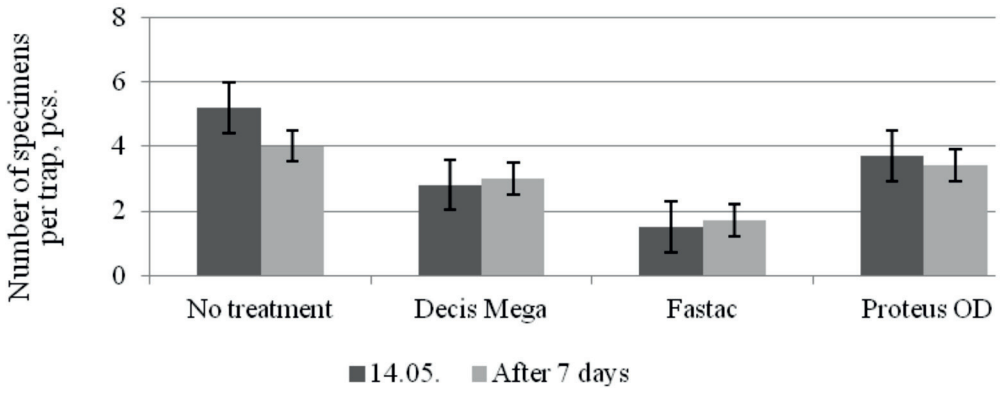
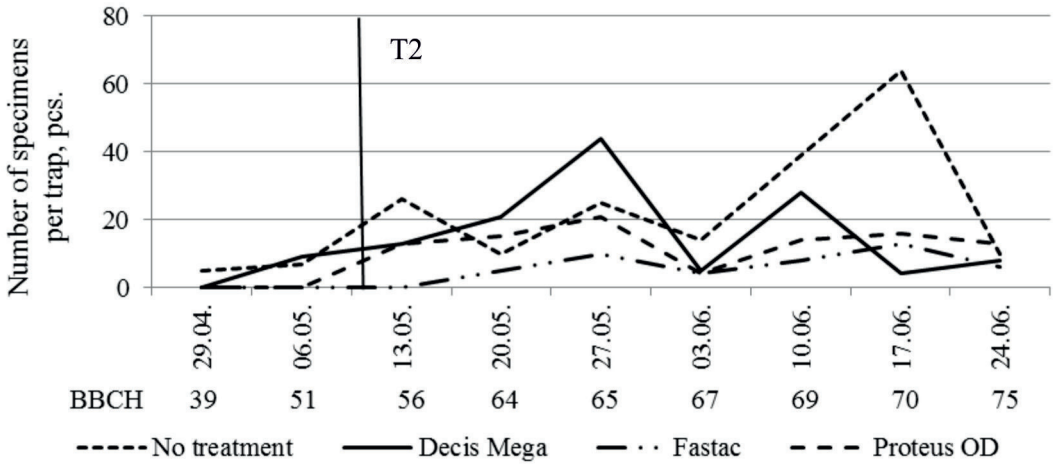


Fig. 7. The average number of *C.obstrictus* specimens per trap (0.03 m^2) in different sowings with and without second insecticide treatment, on May 14 and seven days later, the year 2009.



T2 – second treatment

Fig. 8. The dynamics of *C.obstrictus* specimens in different sowings using synthetic insecticides (T2) and without insecticide application, the year 2010.

at a different time; therefore it is not possible to set the most favourable timing for control of this particular pest (Fig. 6). After second treatment (T2), a positive biological efficiency was observed in sowings where PIR (Decis Mega and Fastac) was applied – 11% and 7% accordingly. There is no explanation for the negative biological efficiency of PIR+NNI (Fig. 7).

The beginning of emergence of cabbage seed weevil was observed on April 29, 2010, but control was done a week later (Fig. 8).

Insecticide spraying together with fungicide was done at the beginning of flowering of oilseed plants. Analysis of the emergence of *C. obstrictus* showed that spraying should have been done a week later, when specimens were observed in all sowings. However, there are data in the literature that in order to minimize the impact on parasitoids of *C. obstrictus*, the control should be performed right after emergence of first specimens (Ulber, Williams, Klukowski, Luik, & Nilsson, 2010). According to the monitoring data of our research, treatment times varied among the sowings. For example, in the sowing where synthetic insecticide Fastac was used, cabbage seed weevil had not yet emerged; therefore that particular spraying should be classified as prophylactic.

A comparatively higher (by 67%) biological efficiency of treatment for *C. obstrictus* control was obtained using PIR+NNI insecticide, but a slightly lower (by 50%) – using PIR (Fig. 9). The highest emergence activity was observed during the seed ripening stage, when pests cannot cause significant damage.

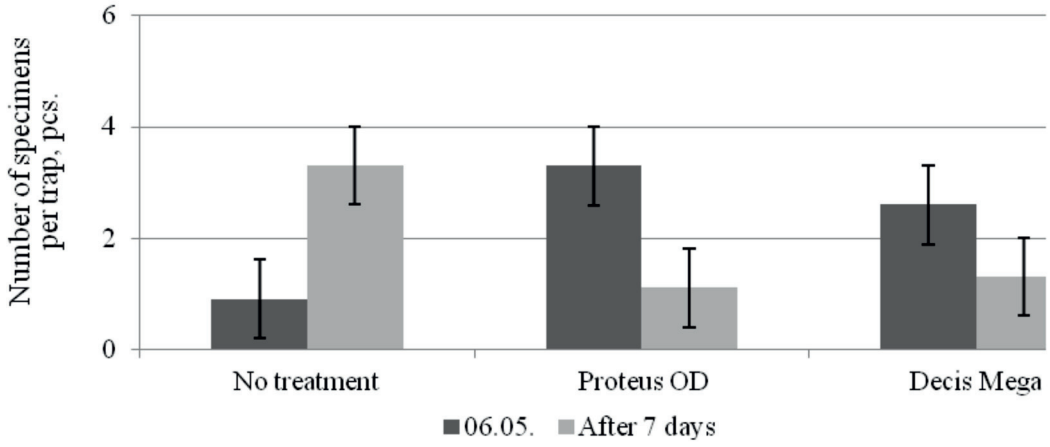
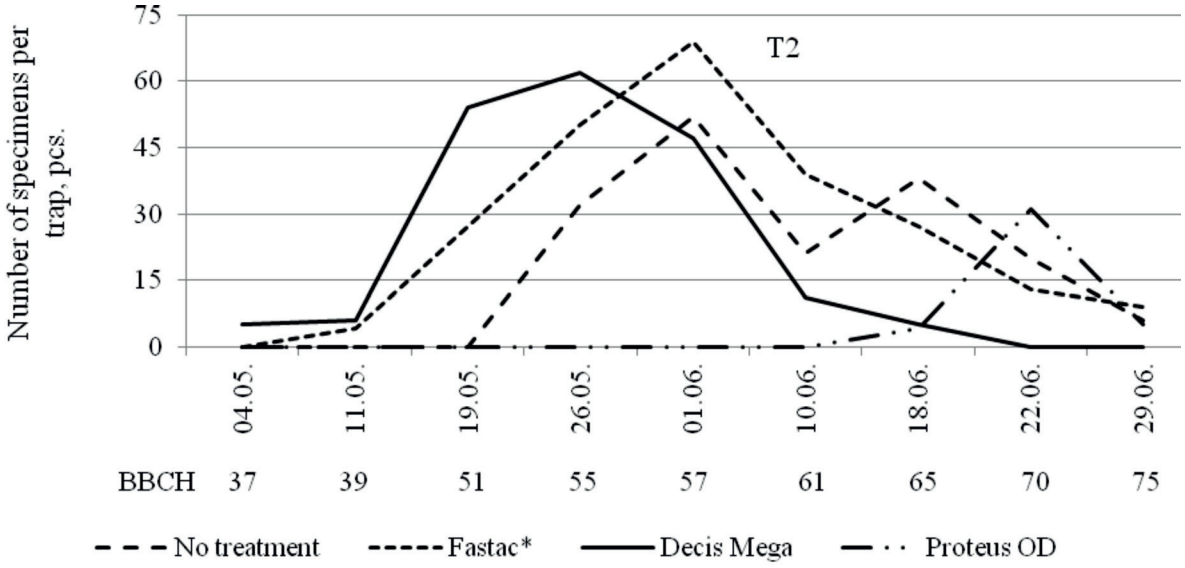


Fig. 9. The average number of *C.obstrictus* specimens per trap (0.03 m^2) in different sowings with and without second insecticide treatment, on May 6 and seven days later, the year 2010.



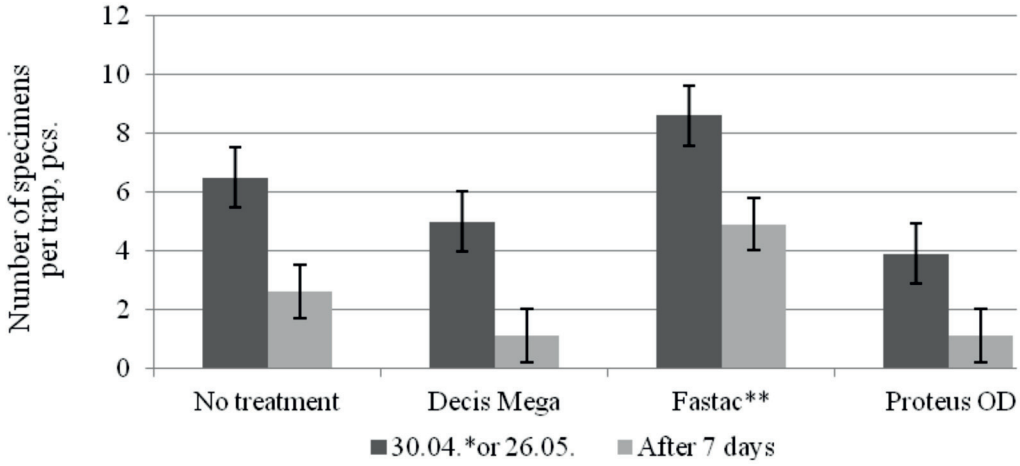
* – treatment with Fastac was done on April 30
T2 – second treatment

Fig. 10. The dynamics of *C.obstrictus* specimens in different sowings using synthetic insecticides (T2) and without insecticide application, the year 2011.

In 2011, second treatment was done by combining control of brassica pests with control of white mould *(Sclerotinia sclerotiorum)*. Monitoring data of cabbage seed weevil emergence demonstrated that limiting of brassica pests was done at the peak of emergence (Fig. 10), whereas in one sowing where *C. obstrictus* control was performed by using Proteus OD, it was visible that the spray had been prophylactic since the emergence had occurred later.

For control of *C. obstrictus*, the greatest biological activity (78%) was observed for treatments with PIR (Decis Mega), a slightly lower (72%) – for PIR+NNI, but only 43% – for sprayings with PIR (Fastac); in the sowing without insecticide treatment, biological efficiency was 60% (Fig. 11). In the surveyed winter oilseed rape sowings, cabbage seed weevil control was dependent on fungicide sprays. According to the literature, fungicides should be applied beginning with the start of flowering until full flowering of oilseed rape plants[2]. However, according to our monitoring data, cabbage seed weevil had not yet emerged in all sowings.

[2] Retrieved March 2012 from http://www.agro.basf.lv/agroportal/lv/media/migrated/lv/productfiles/labels/2010_3/Cantus__L.pdf /



*, ** – treatment with Fastac was done on April 30

Fig. 11. The average number of *C.obstrictus* specimens per trap (0.03m^2) in different sowings with and without second insecticide treatment, on May 26 and seven days later, the year 2011.

The economic threshold for cabbage seed weevil in Latvia has not been determined until now, whereas scientists from the United Kingdom recommend insecticide treatment when two specimens per flowering plant are observed; if brassica pod midge is observed, the threshold is one specimen per plant (Lane & Walters, 1993). However, in most of Europe the economic threshold is 0.5 specimens per plant, except Denmark where six specimens per plant have been observed (Williams, 2010).

Among the synthetic insecticides used in our research, biological efficiency was observed for both PIR+NNI and PIR and none can be noted as superior. This proves the fact that insecticide efficiency is influenced by many factors – plant development stage during spraying, agro-climatic conditions, spray quality, field location and size, pest distribution, and cultivation technology.

In Europe, 31 species of cabbage seed weevil parasitoids whose distribution declines due to use of insecticides have been identified (Kevväi, Veromnn, Luik, & Saarniit, 2006), therefore future studies should find the best compromise between pest control and preservation of parasitoids.

Since no resistance of *Ceutorhynchus* spp. towards active substances of synthetic pyrethroids has been identified in Latvia, pest control is not complicated in this country. However, oilseed rape areas as well as production intensity increase, and neighbouring countries have observed resistance to PIR, which makes us think of the consequences of unreasonable pest control.

In order to reach efficient pest control, it is necessary to monitor the sowings, follow the average daily temperatures, and only then decide on the necessity of pesticide use.

Options for brassica pest control by using synthetic insecticides (PIR and PIR+NNI) have been evaluated; however, not always the obtained results of the biological efficiency were convincing compared to the data from sowings with no insecticide application. This indicates that the control measures used in the present study should be changed.

Conclusions

1. Biological efficiency of synthetic insecticides with the active substances of synthetic pyrethroid and neonicotonoid subclasses for brassica pest control was positive (although with a large interval – from 8% up to 98%) and had a diverse impact on each brassica pest species.
2. Among the synthetic insecticides, Proteus OD, the combined PIR+NNI insecticide, proved to have the highest biological efficiency for cabbage stem weevil control.
3. Although both subclasses of insecticides PIR+NNI and PIR demonstrated a considerable biological efficiency, none of them can be noted as superior for control of cabbage seed weevil. This suggests that effectiveness of insecticide is affected by many factors: plant development stage during the spray, agro-climatic conditions, spray quality, field location and size, distribution of pests, and crop rotation.

4. The currently used pest control measures can be characterized as prophylactic and therefore should not be permitted in integrated pest management.

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