# Poppy root weevils (*Stenocarus ruficornis*, Stephens 1831) control in opium poppy (*Papaver somniferum* L.)

**D. Bečka, P. Cihlář, P. Vlažný, K. Pazderů, J. Vašák**

*Department of Crop Production, Faculty of Agrobiology, Food and Natural Resources, Czech University of Life Sciences Prague, Prague, Czech Republic*

**ABSTRACT**

Effects of insecticidal sprays on poppy root weevils (*Stenocarus ruficornis*, Stephens 1831) were assessed in small plot trials at three localities in the Czech Republic during two years (2011–2012). In addition, the effects of seed dressing were included into the assessment in one of the localities (Červený Újezd). The levels of root damage caused by the insect pest larvae (expressed as number of bore holes per root) and yield got from individual treatments were compared. Sprays applied for 18 days after the first record of poppy root weevils in trials showed the highest effects on a decrease of the levels of root damage (40% of untreated control). In general, sprays applied at the date when $SATF_{14}$ value exceeded 20°C showed significant effects on decreasing the levels of root damage. The highest effects were usually recorded in sprays which were applied when $SATF_{14}$ value exceeded 100°C.

**Keywords**: *Stenocarus ruficornis*; seed treatments; foliar protection; signalization method; air temperature

The opium poppy (*Papaver somniferum* L.) is currently still an important agricultural crop grown for purposes of the food industry in the Czech Republic (Matyášová et al. 2011). With the increasing area where the poppy is grown, the problem of pests becomes more important. One of the most significant pests is the poppy root weevil (*Stenocarus ruficornis*, Stephens 1831).

Since the problem has not been resolved sufficiently, yet, we only have a minimum of information about the insect's behaviour. The insect hibernates as an adult in the ground and in spring migrates to the poppy fields shortly after crop emergence. Adults damage leaves of small plants by eating. After 8 days of eating the insects mate and females begin to lay eggs. The females lay their eggs into the tissue of lower leaves. After short time of browsing in the leaf parenchyma, the larvae burrow into the soil and complete their development on the poppy roots. Newly emerged adults appear in the course of July and stay in environs to the first half of October. So the species has one generation per season (Stanev 1960).

The vegetation is primarily damaged by the larvae, but in the case of high abundance adults can completely destroy the crop, too (Stanev 1960). Sikora (2008) claims, that chemical control at the time of presence of larvae on the roots is no longer effective. Thus it is necessary to take action by applying insecticides at the time when the greatest possible number of adults occur in the crop, preferably before the females start laying their eggs.

Up until the year 2013 growers could rely on registered insecticides, used as seed dressings and/or foliar applications. In 2013 the European Commission approved bill number 485/2013 in which the use of neonicotinoid active ingredients thiamethoxam and clothianidin for a period of at least two years is prohibited. These were contained in registered insecticides used as seed dressings in poppy crops. Thus the grower now must rely only on foliar protection using post-emergent insecticides.

For the paper we drew inspiration from the migration demands and signalisation for similar species of the genus Curculionidae occurring in other crops. Signalisation methods have not been researched for the poppy root weevil. Pitfall traps with attractants were used in Sweden for monitoring the capture of pine weevil, yet (Tilles et al. 1986).

The main goals of this study were (1) to verify the signalisation method based on the use of pitfall traps under field conditions and (2) to determine a suitable schedule for the timing of sprays leading to decreasing adult occurrence and subsequently the damage caused by the larvae. The results can primarily help growers in the coming years, when they only rely on the foliar application of insecticides due to the ban on neonicotinoid active ingredients.

## MATERIAL AND METHODS

In the years 2011 and 2012 precise small-plot experiments were established on opium poppies in three research locations: Červený Újezd (the Prague-West region), Stehelčeves (the Kladno region) and Chrášťany (the Rakovník region).

The research plots and the individual poppy fields were selected on the basis of the long-term growing of poppies in the given areas so that the distance of the newly-established poppy field is not more than 1 km from the previous year's field.

The research locations at the locations had a precise size of 15 $m^2$ and 12 $m^2$ for harvesting, always in four repetitions. The experiments took place on treated (Červený Újezd, Chrášťany, Stehelčeves) and untreated (Červený Újezd) seeds of the high-oleic poppy cv. Major. For seed treatment, Cruiser OSR (thiamethoxam, metalaxyl-M, fludioxonil) was used in the volume of 25 L per one tonne of seed stock. The plants were exposed to a natural infestation of the target pest.

The meteorological data for Stehelčeves were collected from the Prague-Ruzyně meteorological station (10 km away), for Červený Újezd from the local meteorological station (0.5 km away) and for Chrášťany from the company's meteorological station (4 km away). For the calculation we used our modified flight simulation method using flight curves depending on the sum of air (2 m) temperatures (Šedivý and Kocourek 1994). Seeing that the method is intended for winter oilseed rape and that the weevils are especially attracted with poppy plant odours in the course of poppy filed occupation, we started to calculate the temperatures at the time when the poppy started to emerge (BBCH 10). In this case the temperatures are not related to the flight activity. In the growth we used pitfall traps and thus the values are related to the activity of the beetles in the growth. We defined the SATF values as the maximum daily temperature, which exceeds the threshold of 14°C (Vašák 2010). Days with maximum daily temperatures below 14°C were not taken into account. Thus the formula for this method was:

$$\mathrm{SATF} = \Sigma t_{max} - \mathrm{PTL}$$

Where: $t_{max}$ – sum of the daily maximum temperatures exceeding 14°C recorded from BBCH 10; PTL – threshold value for the activity of the poppy root weevil – +14°C (Table 1).

In the individual locations four pitfall traps of our own production were placed diagonally in terms of the entire plot on the untreated area (which included the small-plot trials). The traps are plastic boxes (150 × 100 × 50 mm) with an opening (100 × 70 mm) cut into the lid. Non-drying Chemstop paste (Atactic polypropylen 30%, polyolefins 70%) is smeared on the bottom of this modified lid. Replanted winter oilseed poppy is inside in the soil substrate (= the attractant). The trap is located in the growth and after 3–4 days the trap is emptied and the number of the pests is evaluated. We repeated this activity 8 times in each location.

The registered Cyperkill 25 EC preparation (active ingredient cypermethrin) in a dosage of 0.1 L/ha was chosen for the application of the insecticide.

We specified the D date as the date when adults from the wintering generation of poppy root weevils were first found in at least one of the four pitfall traps.

Three (Stehelčeves, Chrášťany) or four (Červený Újezd) times of spraying were included and compared in the field trials:

1. Date D + 3 – application 3 days after finding the first adults in the crop.
2. Date D + 8 – application 8 days after finding the first adults in the traps – the goal is to protect the crop at the time when most adults should be present in the crop and, at the same time, before the beginning of egg-laying period (Schreier 1997).
3. Date D + 18 – application 18 days after finding the first adults in the traps – the goal is to protect the crop at the time when the flight activity and the presence of beetles in the crop is still continuing and the first eggs have already been laid.
4. Date D + 24 – application 24 days after finding the first adults in the traps – the goal is to assess an effect of such very late application.

The experiments were evaluated in BBCH 46. Thus in each variation 40 plants were evaluated. The larval notches of the poppy root weevil larvae were counted on the roots and the yield of the seed at the end of the vegetation was evaluated.

The statistical processing of the data was performed using the SAS system (version 9.2, Carry,

Table 1. Dates, BBCH growth phases (the portion of the plants in the higher growth phases are given in parentheses) and the $SATF_{14}$ application of the individual variations of the insecticide in the years 2011 and 2012

| Location | Year | Sown | D date | D date + 3 | D date + 8[1)] | D date + 18 | D date + 24 |
|---|---|---|---|---|---|---|---|
| | | | | | BBCH $SATF_{14}$ (°C) | | |
| Červený Újezd | 2011 | 30.3 | 19.4.<br>10–22 (20%)<br>12 | 22.4.<br>10–22 (40%)<br>35 | 28.4.<br>10–24 (40%)<br>56 | 7.5.<br>10–25 (30%)<br>78 | 13.5.<br>10–26 (30%)<br>119 |
| | 2012 | 22.3 | 20.4<br>10–14 (60%)<br>4 | 23.4.<br>10–22 (20%)<br>4 | 28.4.<br>10–24 (30%)<br>40 | 8.5.<br>14–25 (30%)<br>116 | 14.5.<br>14–26 (20%)<br>150 |
| Stehelčeves | 2011 | 15.3. | 18.4.<br>10–24 (60%)<br>8 | 21.4<br>12–24 (80%)<br>27 | 26.4.<br>14–25 (50%)<br>67 | 6.5.<br>22–27 (30%)<br>85 | – |
| | 2012 | 20.3 | 20.4<br>10–14 (70%)<br>4 | 23.4.<br>10–22 (30%)<br>6 | 28.4.<br>10–24 (40%)<br>44 | 8.5.<br>14–25 (40%)<br>126 | – |
| Chrášťany | 2011 | 30.3. | 6.5.<br>10–24 (10%)<br>21 | 9.5.<br>10–24 (20%)<br>42 | 16.5.<br>10–24 (50%)<br>82 | 24.5.<br>22–25 (30%)<br>151 | – |
| | 2012 | 21.3. | 20.4.<br>10–14 (50%)<br>5 | 23.4.<br>10–22 (30%)<br>5 | 28.4.<br>10–24 (40%)<br>45 | 8.5.<br>14–26 (20%)<br>125 | – |

[1)]In 2011 variant D + 8 was sprayed a day later, i.e. 28.4.

USA). ANOVA (GLM procedure) program for all the data sets followed by the Tukey's *HSD* multiply range test for the purpose of the multiple comparison of the variations' averages amongst themselves ($P < 0.05$).

## RESULTS AND DISCUSSION

**The results of the occurrence of poppy root weevils in pitfall traps depending on the temperature**. The occurrence of beetles during the course of the experiment was influenced by year and locality. We recorded a higher occurrence of the adults in traps in 2012 ($1.79^a$) than in 2011 ($1.03^b$). The largest number of beetles during the whole period of monitoring was recorded in Stehelčeves ($1.71^a$) and a lower occurrence was recorded in Chrášťany ($1.36^b$) and Červený Újezd ($1.17^b$).

The increase of the captures of adult weevils in the traps depending on the increase of the sum of the effective temperatures over the course of the monitored period is evident from the result in Figure 1. The occurrence of adults and apparently also their activity in the crops increase gradually. While, during the first sampling we captured an average of $0.70^d$ adults per trap, $2.35^a$ adults per trap were recorded on the eight counts. When averaging the years and the locations, the average value of $SATF_{14}$ for D + 3 was 19.8°C, for D + 8 55.6°C and for D + 18 113.5°C. This would correspond with the research by Cakar (1960), who determined that hatched beetles, following a short autumn browsing, crawl back into the soil to a depth of 3 cm to 21 cm and most of them winter at the depth of 10 cm. The slow warming of the soil could then be the cause of the adults gradually leaving their wintering places. On the basis of the results with the bore holes on the roots specified below in the text in connection with the values of $SATF_{14}$ we determined a suitable date for the treatment against adult poppy root weevils. The least amount of the damage to the roots by the poppy root weevil larvae occurred when $SATF_{14}$ reached more than 100°C from the emergence of the poppy, but the treatment was already effective (in terms of yield) when the value of $SATF_{14}$ was at 20°C.

**Damage to the poppy roots by the poppy root weevil larvae**. The differences in the roots damage

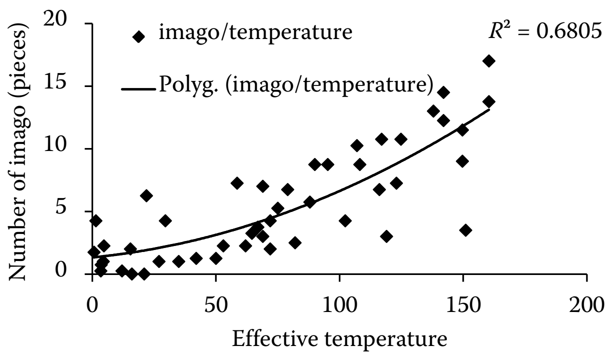


Figure 1. Correlation between the mean cumulative weevils' captures in traps and the increase in values of sums of effective temperatures in the course of time. The data obtained at all localities in all three seasons are plotted in the graph

levels induced by larvae showed to be statistically significant in relation to the season and location. The location with the greatest number of larval bore holes on the roots was Červený Újezd – 7.71[a]. The main reason, compared to the other locations (Stehelčeves – 1.89[b] and Chrášťany 1.32[c]), is apparently the size of the area of the poppy field. At the Červený Újezd location the poppy field always had approximately 1.5 ha, while at the remaining localities the experiments were based on operating areas with sizes always exceeding 10 ha. Just like in the experiments with rape (Zaller et al. 2008), there will be a dependency between the size of the poppy area and the concentration of pests, where the larger the area, the lesser damage to the poppies.

**Foliar application of insecticide and its influence on the decrease on the number of bore holes by larvae on the roots and the seed yield**. The supplementary application of insecticides always significantly decreased the number of bore holes on the roots (Table 2). Rotrekl (2008) expresses a similar claim, stating that if we want to ensure perfect protection for poppies, it is necessary to use foliar application after the treatment subsides and when the beetles appear in the crop. Kazda et al. (2005) also arrived to similar results on winter oilseed rape with the turnip gall weevil (*Ceutorhynchus pleurostigma*), where it was confirmed that the foliar application of insecticide was always better than the treatment of seeds alone.

In Table 2 we can see the differences in the number of larvae bore holes on the roots in the individual years and among the individual locations. Statistically, the differences compared to the control were not confirmed only in the Chrášťany location in 2011, when the overall occurrence of the specimens at this location was very weak. All of the foliar applications had an influence on the subsequent damage on the roots caused by the larvae. The later treated variants (D + 18) had the least bore holes on the roots.

Table 2 also shows that each supplementary spray applied to the crop originated from treated seed-stock increased the yield. The differences between the individual insecticidal treatments were not completely significant in the two years and three locations, but the control differed from all other sprayed treatments.

**The significance of seed treatment on the number of bore holes on the roots and the yield**. Poppy plants are very vulnerable to abiotic and biotic stresses in the early growth phases. It is very difficult to determine the factor that influenced the yield in a given year. For the treated variations we used Cruiser OSR as a seed treatment with the active insecticide ingredient being thiamethoxam (and with two fungicidal substances fludioxonil and metalaxyl-M). A treatment with the active ingredient from the same chemical group was also

Table 2. Average number of bore holes induced by poppy root weevil larvae on a single poppy root in the individual locations in the individual years and the total yield (t/ha) of the variations

| | 2011 | | | 2012 | | | 2 years 3 locations | |
|---|---|---|---|---|---|---|---|---|
| | Červený Újezd | Stehelčeves | Chrášťany | Červený Újezd | Stehelčeves | Chrášťany | bore holes | yield |
| Control | 5.45[a] | 4.25[a] | 1.00[a] | 15.10[a] | 2.08[a] | 3.50[a] | 5.50[a] | 1.50[b] |
| D + 3 | 3.80[b] | 1.90[b] | 0.90[a] | 10.55[b] | 0.68[b] | 1.80[b] | 3.40[b] | 1.71[a] |
| D + 8 | 2.70[bc] | 1.75[b] | 0.73[a] | 11.20[b] | 1.95[a] | 1.53[bc] | 3.40[b] | 1.73[a] |
| D + 18 | 2.20[c] | 1.25[b] | 0.50[a] | 6.73[c] | 1.28[b] | 0.68[c] | 2.20[c] | 1.70[a] |
| *HSD* | 1.59 | 0.92 | 0.59 | 2.87 | 0.67 | 0.99 | 0.60 | 0.17 |

Means marked with the same letter are not statistically different at the level $P$ = 0.05

Table 3. Average numbers of bore holes related per one root and recorded yields (t/ha) on the locality Červený Újezd

| | 2011 untreated | Yield | 2011 treated | Yield | 2012 untreated | Yield | 2012 treated | Yield |
|---|---|---|---|---|---|---|---|---|
| Control | 7.30[a] | 1.75[a] | 5.45[a] | 1.97[a] | 15.10[a] | 0.74[a] | 7.80[a] | 0.88[a] |
| D + 3 | 5.10[b] | 1.94[a] | 2.70[bc] | 2.10[a] | 10.55[b] | 0.82[a] | 6.35[ab] | 0.98[a] |
| D + 8 | 3.30[c] | 2.10[a] | 3.80[b] | 2.17[a] | 11.20[b] | 0.78[a] | 7.25[a] | 0.90[a] |
| D + 18 | 2.50[c] | 1.86[a] | 2.20[c] | 2.07[a] | 6.73[c] | 0.86[a] | 4.98[bc] | 1.04[a] |
| D + 24 | 2.40[c] | 1.88[a] | 1.90[c] | 2.07[a] | 5.45[c] | 0.92[a] | 3.83[c] | 1.03[a] |
| *HSD* | 1.39 | 0.52 | 1.59 | 0.72 | 2.87 | 0.48 | 1.96 | 0.33 |

Means marked with the same letter are not statistically different at the level $P = 0.05$

used in rape. According to Kazda et al. (2005) the seed dressing provided protection against pests for 4–5 weeks in winter oil seed rape.

As we can see in Table 3, the occurrence of larvae on the roots on the treated control in 2012 did not differ statistically from the dates D + 3 and D + 8 and more serious attacks on the poppies and laying of eggs occurred after these dates. With the untreated seeds there was a significant reduction of adults (and thus also a subsequent decrease of the damage to the roots by larvae) with the first foliar application in 2012.

The yields for both years confirmed the differences between the treated and untreated seed. In the year 2012 it was 0.98[a] t/ha (treated) compared to 0.81[b] t/ha (untreated) and in the year 2011 2.08[a] t/ha (treated) and 1.90[b] t/ha (untreated).

In conclusion, this work (a) confirms the existence of a dependency between the gradual increase in the occurrence of adults of poppy root weevils in the emerging poppy and the gradual increase of the sum of effective temperatures (over 14°C) calculated from the beginning of the emergence of the poppies; (b) confirms the beneficial influence of the treatment of poppies on the yield and reduction of the damage to the roots by poppy root weevil larvae; (c) demonstrates the higher effectiveness of foliar applications performed on relatively later dates (D + 18, D + 24) compared to earlier applications (D + 3) in relation to the course of monitoring of the adults of occurrence in the growth and the gradual increase of the sum of effective temperatures.

## REFERENCES

Cakar L. (1960): A contribution to the knowledge of *Stenocarus fuliginosus*. Zaštita Bilja Plant Protection, *57–58*: 183–202.

Commission implementing regulation (EU) No 485/2013 of 24 May 2013. Official Journal of the European Union L139, 12–26. Available at http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2013:139:0012:0026:EN:PDF

Kazda J., Baranyk P., Nerad D. (2005): The implication of seed treatment of winter oilseed rape. Plant, Soil and Environment, *51*: 403–409.

Matyášová E., Novák J., Stránská I., Hejtmánková A., Skalický M., Hejtmánková K., Hejnák V. (2011): Production of morphine and variability of significant characters of *Papaver somniferum* L. Plant, Soil and Environment, *57*: 423–428.

Rotrekl J. (2008): Principle of Poppy Protection (*Papaver somniferum* L.) against Insect Pests. Research Institute of Fodder Crops, Troubsko, 16. (In Czech)

Schreier J. (1997): Poppy root weevil – serious pest of opium poppy. Agro – Plant Protection and Nutrition of Crops, *3*: 36–38. (In Czech)

Sikora K. (2008): Protection of opium poppy (*Papaver somniferum* L.) against poppy root weevil (*Stenocarus ruficornis*) by foliar application. Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis, *56*: 123–130. (In Czech)

Stanev M.Z. (1960): Poppy root weevils (*Stenocarus fuliginosus* Marsh. and *Ceutorhynhus maculaalba*), a potential candidate for the biological control of opium poppy, *Papaver somniferum* L. Environmental Entomology, *9*: 681–688.

Šedivý J., Kocourek F. (1994): Flight activity of winter rape pests. Journal of Applied Entomology, *117:* 400–407.

Tilles D.A., Sjödin K., Nordlander G., Eidmann H.H. (1986): Synergism between ethanol and conifer host volatiles as attractants for the pine weevil, *Hylobius abietis* (L.) (Coleoptera: Curculionidae). Journal of Economic Entomology, *79*: 970–973.

Vašák J. (ed.) (2010): Poppy. Powerprint, Praha. (In Czech)

Zaller J.G., Moser D., Drapela T., Schmöger C., Frank T. (2008): Effect of within-field and landscape factors on insect damage in winter oilseed rape. Agriculture, Ecosystems and Environment, *123*: 233–238.

Received on May 21, 2014
Accepted on September 11, 2014

*Corresponding author:*
Ing. David Bečka, Ph.D., Česká zemědělská univerzita v Praze, Fakulta agrobiologie, potravinových a přírodních zdrojů, Katedra rostlinné výroby, Kamýcká 129, 165 21 Praha 6-Suchdol, Česká republika
e-mail: becka@af.czu.cz