Effect of Flight Activity of Stem Weevils (*Ceutorhynchus napi, C. pallidactylus*) and Application Time on Insecticide Efficacy and Yield of Winter Oilseed Rape

Tomáš SPITZER[1], *Pavel MATUŠINSKÝ*[1], *Dagmar SPITZEROVÁ*[1], *Jan BÍLOVSKÝ*[1] *and Jan KAZDA*[2]

[1]*Agrotest fyto, Ltd, Kroměříž, Czech Republic;* [2]*Department of Plant Protection, Faculty of Agrobiology, Food and Natural Resources, Czech University of Life Sciences Prague, Prague, Czech Republic*

Abstract

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During 2010–2012, we monitored flight activity of male and female stem weevils (*Ceutorhynchus napi, C. pallidactylus*) using yellow water traps, the effectiveness of various application dates for the insecticide thiacloprid (72 g active ingredient/ha), and the influence on yield. The first occurrence of beetles in traps was recorded after soil temperature at 5 cm reached 8°C in all experimental years. In all years, males of *C. pallidactylus* dominated in the traps and the times of beetles' first occurrence. The most effective applications of thiacloprid at the stated rate were 14 days (2010), 6 days (2011), and 1 day (2012) after peak flight. Females with eggs appeared in bowls in 2010 and 2012 at first flight, while in 2011 no females were recorded. After the most effective applications, yields increased significantly in 2010 (+5% vs. the control) and in 2011 (+4%), and insignificantly in 2012 (+2%).

Keywords: cabbage stem weevil; oilseed rape stem weevil; thiacloprid; yellow water traps

In the Czech Republic, the growing of winter oilseed rape has held steady at 300 000 ha in recent years and the crop is raised on more than 11% of the arable land. On many farms specialised in growing oilseed rape, its proportion in the crop rotation is much higher and reaches as high as 30%. This intensive cultivation has brought increased incidence of some pests. Among these, the cabbage stem weevil (*Ceutorhynchus pallidactylus* [Marsham, 1802]) and oilseed rape stem weevil (*C. napi* [Gyllenhal, 1837]) are the most important (Rotrekl 2000; Kazda 2002, 2004; Seidenglanz 2006, 2007). Farmers do not usually differentiate between the two species, and they are simply referred to together as stem weevils (Šedivý & Kocourek 1994). The timing of insecticide treatment is generally based upon monitoring the stem weevils' flight activity using yellow water traps. Spraying is recommended when the number of adults captured exceeds damage thresholds of 4–6 *C. napi*/3 days/trap and 12 *C. pallidactylus*/3 days/trap (Šedivý 2000). *C. napi* is considered to be somewhat more noxious than is *C. pallidactylus* because its egg laying and larval development occurs in the stem from the start, while *C. pallidactylus* lays eggs into leaf petioles and the larvae move to the stems later (Šedivý & Kocourek 1994; Kazda 2004).

It has been confirmed experimentally that male and female cabbage stem weevils leave their hibernation sites at distinctly different times (Büchs 1998; Klukowski 2006). Seidenglanz *et al.* (2009) report that these differences in flight activity characteristics result in a distinct variability in the levels of plant infestation and that the decisive factors substantially influencing the final levels of plant infestation by larvae are the actual number of females in the catches at the time of the first appearance of females with

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ripe eggs in their ovarioles and the actual duration of the egg-laying period.

The insecticide Biscaya 240 OD (active ingredient thiacloprid 240 g/l) has been approved for use in the Czech Republic against stem weevils. It was selected for the experiments because it is relatively harmless to bees and it may be used also at higher temperatures. Its application times at intervals can go to as late as the end of April and early May, when daytime temperatures can reach levels in which pyrethroid-based insecticides are ineffective.

The objective of the work was to determine whether the timing of stem weevils' spring flight activity and the incidence of females in yellow traps influence the efficacy of insecticide treatment and crop yield.

MATERIAL AND METHODS

The place of the field experiments ranks among the most fertile lands in the Czech Republic. The country is situated in the Central-European climatic zone (49°17'13.708"N, 17°22'13.296"E). Climatically, this area is warm and slightly humid with mean annual temperature of 8.7°C and total annual precipitation of 599 mm.

The experiments were conducted in 2010, 2011, and 2012. Seeding, fertilization, and protection from pathogens were carried out conventionally in accordance with good agricultural practices. The field trials were conducted on plots of 25 m^2, with each variant in four repetitions in a random arrangement. Harvest was made using a Sampo 2010 plot combine harvester equipped with automatic weighing equipment and moisture detector. Yields were recalculated to the standard 8% moisture content and yield differences in the individual years vs. the controls were calculated in percentage terms. Temperature and precipitation data for the Agrotest fyto, s.r.o. research institute are presented in Figures 1 and 2. Soil temperature data at 5 cm were obtained from an automated meteorological station located on the premises of Agrotest fyto, s.r.o., Kroměříž, 1 km from the experimental plot.

Four yellow traps filled with water with a surfactant (Jar Lemon commercial dishwashing soap, Procter & Gamble Co.) in concentration of 0.01% were placed at the corners of the experimental field (100 × 100 m spacing). The traps were checked at 3-day intervals and insect catches were transported to a laboratory for analysis. Individuals of the genus *Ceutorhynchus* were separated into species. *C. pallidactylus* and *C. napi* were counted. Females of both species were dissected and examined for the presence of eggs in ovarioles. In this respect, the females were divided into two categories: (1) females without visible eggs in the abdominal cavity, and (2) females with the abdominal cavity completely or almost completely filled with larger, yellowish eggs.

The insecticide Biscaya 240 OD (active ingredient thiacloprid 240 g/l, produced by Bayer) was applied at

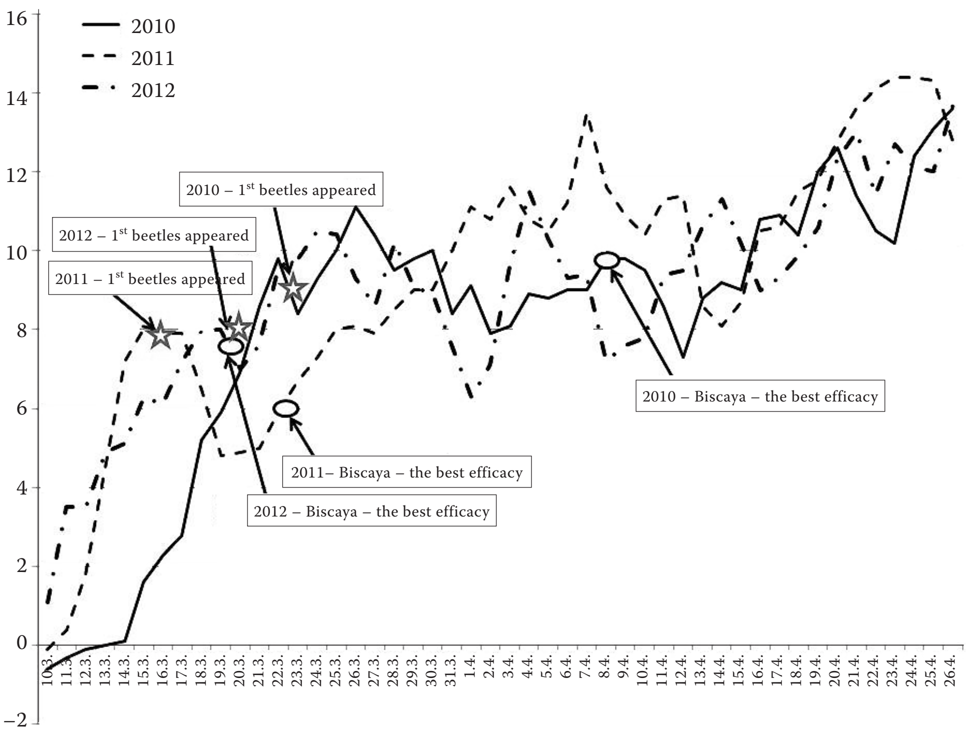

Figure 1. Temperature at the Research Institute Agrotest fyto, s.r.o.

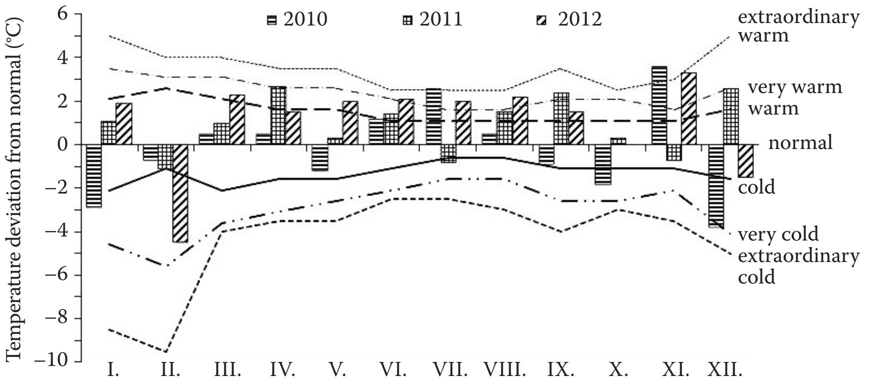

Figure 2. Precipitation at the Research Institute Agrotest fyto, s.r.o., Koměříž, Czech Republic

1-week intervals at the recommended field rate (0.3 l/ha; water: 300 l/ha) in the trials. The first insecticide treatment was always carried out at the beginning of flight activity (when the first weevils were recorded in the yellow water traps) or shortly before that time, depending on weather conditions in the early spring which made the application technically feasible. In 2010, the first weevils appeared on March 22 and the first insecticide application was made on March 18. In 2011, the first appearance was on March 16 and the first insecticide application was on March 22. In 2012, the first appearance was on March 19 and the first insecticide application was on March 20. Four insecticide applications were made in 2010, five in 2011, and six in 2012. The applications were discontinued when the rape reached the BBCH 55 development stage (individual flower buds on main inflorescence visible), as in this period infestation by pollen beetles can occur, and it is necessary to apply insecticide against them. A small-plot residue-free backpack sprayer (R&D Sprayers,) was used.

The efficacy of treatments was evaluated at the end of anthesis, when the oilseed rape was at growth stage BBCH 65–69. Twenty plants were selected at random in accordance with European and Mediterranean Plant Protection Organisation standard PP 1/219(1) and larvae of the genus *Ceutorhynchus* in stems and leaf-stalks were counted. The two species were not differentiated and only the total number of larvae per stem and leaf-stalks (together) were determined. Larvae of the two weevil species are very difficult to distinguish from one another.

The data for mean number of larvae (sums per treatment and per stem) and yield were statistically analysed using STATISTICA 7.0 software for statistical analysis by regression and the Analysis of variance (ANOVA). Subsequently, the differences among the mean values were tested using Tukey's test ($P < 0.05$).

RESULTS

Application times, numbers of larvae, and yields for insecticide treatments in individual experimental seasons are summarized in Table 1.

In 2010, the first appearance of stem weevils in yellow water traps was on March 22. Flight activity peaked on March 24 when 140 adult stem weevils were detected in the four yellow traps. Almost all of them were *C. pallidactylus* and included 127 males and 13 females (6 females with eggs). There were additionally 4 males of *C. napi*. Flight activity continued until the second half of April, but all other catches

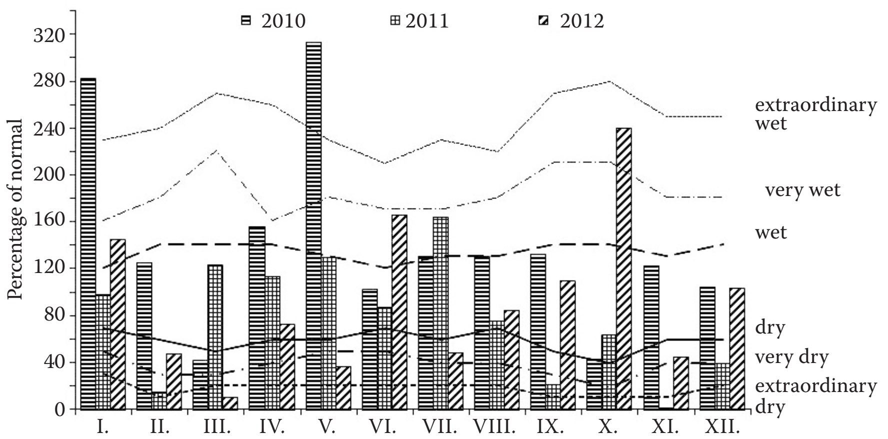

Figure 3. Mean daily soil temperature (°C) at 5 cm-depth (X-axis), flight activity of stem weevils in yellow traps and application time of insecticides with the highest efficacy against stem weevil in the experiments in 2010–2012

Table 1. The effects of insecticide application on the number of stem weevil larvae in plants

Treatment	Date	Mean number of larvae		Yield	
		Σ/treatment	per stem	(t/ha)	control (%)
2010					
Untreated control		232	11.6	2.74	
Biscaya 240 OD	March 18	224	11.2	2.75	100
Biscaya 240 OD	March 26	177*	8.9*	2.83	103
Biscaya 240 OD	March 30	123*	6.2*	2.82	103
Biscaya 240 OD	April 8	59*	3.0*	2.87*	105
SE		1.375	0.105	0.015	
The first occurrence of adults in yellow traps – March 22, 2010; Top of flight activity – March 24, 2010					
2011					
Untreated control		46	2.3	4.16	
Biscaya 240 OD	March 22	6*	0.3*	4.33*	104
Biscaya 240 OD	March 29	39	2.0	4.36*	105
Biscaya 240 OD	April 5	28	1.4	4.08	99
Biscaya 240 OD	April 12	24*	1.2*	4.21	100
Biscaya 240 OD	April 19	37	1.9	4.24	101
SE		1.787	0.143	0.050	
The first occurrence of adults in yellow traps – March 16, 2011; Top of flight activity – March 16, 2011					
2012					
Untreated control		112	5.6	3.58	
Biscaya 240 OD	March 20	56*	2.8*	3.64	102
Biscaya 240 OD	March 28	87	4.4	3.44	96
Biscaya 240 OD	April 4	64	3.2	3.46	97
Biscaya 240 OD	April 18	59	3.0	3.58	100
Biscaya 240 OD	April 25	88	4.4	3.52	98
Biscaya 240 OD	May 2	71	3.6	3.60	101
SE		1.503	0.121	0.016	
The first occurrence of adults in yellow traps – March 19, 2012; Top of flight activity – March 19, 2012					

*significant at 0.05 level of probability

were low, at just 1 or 2 beetles per week. Throughout the monitoring, primarily males and a much smaller number of females were found in the traps. The lowest level of larvae infestation was recorded after the treatment made at the last application date (April 8, 2010). The positive effect of the spraying on yield was significant ($P < 0.05$). Increased yield of 5% was recorded in comparison with the untreated control.

In 2011, the first stem weevils in yellow water traps appeared on March 16. The overall flight activity of stem weevils was very low in this season and only 16 individuals (14 adults of *C. pallidactylus* and two adults of *C. napi*) were found in all traps through the entire monitoring period. All adults were identified as males. The lowest number of larvae in plants was recorded after the treatment sprayed 6 days after the recording of the first adults in traps. This application period also significantly influenced yield, which increased by 4% when compared with the untreated control.

In 2012, the first occurrence and simultaneously the peak of flight activity were observed on March 19. In total, 160 individuals were found in the four traps at that date. These comprised 147 *C. pallidactylus* adults, including 6 females (1 with eggs), and 7 males of *C. napi*. Flight activity continued until early April, but the catches markedly decreased and no females were recorded thereafter at all. The lowest number of larvae in plants was recorded after the treatment sprayed 1 day after the recording of the first weevils in traps. None of the compared applications influenced yield significantly.

Figure 3 illustrates the first flight activity of stem weevils relative to soil temperature at a depth of 5 cm as well as the highest efficacy of insecticide application in particular years.

The importance of 5 cm soil temperature for stem weevils to begin leaving their overwintering sites and to initiate flight activity seems to have been confirmed. In all three years, an average soil temperature (at 5 cm) around 8°C was crucial. In 2010, that temperature was recorded on March 21, the first stem weevils appeared in traps on March 22, and high flight activity continued until March 24. In 2011, a temperature around 8°C was reached on March 15 and the first weevils appeared in traps on March 16. Then the temperatures markedly decreased and no other weevils were captured until March 25 since when the soil temperature went up again. In 2012, the soil temperatures reached 8°C on March 18 for the first time. The first appearance as well as the greatest flight activity were recorded on March 19.

DISCUSSION

The relationship between soil temperature and the flight activity of stem weevils has been reported by Bűchs (1998). The adults begin leaving their overwintering sites when the soil temperature at 5 cm is fluctuating around 6°C. According to other authors, mostly from countries in southern Europe (Sekulič & Kereši 1998; Juran *et al*. 2011), this occurs only when the temperature in the top layer of soil rises to 9–10°C. In the case of the closely related species *Ceutorhynchus obstrictus* (Marsham, 1802), Ulmer and Dosdall (2006) and Carcamo *et al.* (2009) have proven that flight activity usually begins when the soil temperature at 5 cm fluctuates near 15°C. Our recording of the beetles' first flight activity upon reaching 5 cm soil temperature around 8°C is in accordance with the findings of other authors.

The use of thiacloprid against stem weevil is not yet usual in the Czech Republic, even though the preparation Biscaya 240 is approved for use against these pests in winter oilseed rape. However, thiacloprid has high potential for use against weevils because, as Heimbach and Müller (2012) report, "in the German region with the longest tradition and high intensity of oilseed rape production, pyrethroid resistance of *Psylliodes chrysocephala* (L.) and *Ceutorhynchus obstrictus* (Marsham), with resistance factors of up to 81 and 140 respectively, was detected".

Thiacloprid has been developed especially for foliar treatments and has very good systemic and contact effect. Moreover, these benefits are combined with a relatively low application rate, superior plant compatibility in various crops (canola, cereals, cotton, fruits, oilseed rape, rice, etc.). Not only is Thiacloprid effective against adult beetles, it also is active against larvae and eggs. One other major advantage is that it has no effect on pollinating insects, such as honey bees, bumble bees, and parasitic wasps (Schirmer *et al*. 2012).

The effectiveness against stem weevils (*C. napi* and *C. pallidactylus*) of products containing the active ingredients deltamethrin + thiacloprid and cypermethrin + chlorpyrifos was monitored by Tancik and Bokor (2012). The application of the products with deltamethrin + thiacloprid and cypermethrin + chlorpyrifos was at the time of the main infestation by adult stem weevils, and the effectiveness of both combinations was high.

The efficacy of the insecticide Biscaya 240 OD varied greatly depending on the application time in particular years. Even at the application time providing the best efficacy, plants with larvae were present. In the most effective treatment, the average number of larvae per plant was 3 individuals (untreated control 11.6 individuals) per plant in 2010, 0.3 individuals (control 2.3 individuals) per plant in 2011, and 2.8 individuals (control 5.6 individuals) per plant in 2012.

Seidenglanz *et al.* (2009) compared the effects of two pyrethroids and one combination of organophosphate and pyrethroid (alpha-cypermethrin, etofenprox, chlorpyrifos + cypermethrin) against *C. pallidactylus.* The effectiveness of the tested insecticides was markedly influenced by the time of spraying. Only at the optimal spraying time did the effects of the pyrethroids applied individually achieve results comparable to those of the chlorpyrifos + cypermethrin combination.

The assumption that the monitoring of females in yellow traps can lead to a more precise date for optimum insecticide treatment was confirmed. Seidenglanz *et al.* (2009) report the actual number of females in the catches and the active duration of females' having ripe eggs as decisive factors which substantially influenced the final level of plant infestation with larvae. The application date had a substantial influence on the final insecticidal effect. In two monitored years, the most effective insecticide applications were at the time when females were found in yellow traps. In 2010, the flight activity of the weevils was very long (from March 22 to April 21). The first females emerged with a 3-day delay after the first flight activity, when only males were caught. At other times, high numbers of adults were not recorded in the traps but females were always captured. The efficacy of the insecticide applications gradually increased from the first catch of females. The insecticide application time used by farmers in that year after they had detected the main flight activity of stem weevils through their monitoring with yellow traps was characterized by very low efficacy. On the contrary, the insecticide was most effective at the later application time, 16 days after the first flight activity, namely at the time when females were also present in the traps. The flight activity was short in 2012, and even females with eggs were caught at the time of the first flight activity in that year. The best efficacy was obtained after the insecticide application immediately following the first flight activity monitored in yellow traps. In 2012, the usual application time and the time determined according to the flight activity of females coincided. In 2011, the flight activity of stem weevils monitored in yellow traps was very low and only males were caught. Thus, the time of application could not be compared.

In 2010 and 2011, the yield increased significantly after applications at times when the efficacy of insecticides was the highest. However, the yield increase did not exceed 5%. Among the total of 15 insecticide applications carried out during 2010–2012, the yield increased significantly in three cases only. These findings lend support to suggestions that the current threshold values should be revised for stem weevils (the damage from which appears to be overestimated) as well as the effort to determine a more precise time for insecticide application.

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Corresponding author:

RNDr. Tomáš Spitzer, Ph.D., Agrotest fyto, s.r.o., Havlíčkova 2787, 76701 Kroměříž, Česká republika; E-mail: spitzer@vukrom.cz