Control by Seed Dressing of Leaf Weevils of the Genus *Sitona* (Col.: Curculionidae) Feeding on Sprouting Alfalfa

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Abstract

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In tests with artificial infestation of alfalfa by leaf weevils in the greenhouse and also in small-plot trials with natural infestation of sprouting alfalfa it was found that without protection alfalfa is seriously damaged by leaf weevil feeding. After evaluation of the feeding damage by weevils, the damage to plants in the untreated plot was classed as 3rd, 4th and 5th degree on a five-level scale. Plant growth was seriously restricted and in warm and dry weather plants may die. The results demonstrate that in both kinds of trials the pre-sowing treatment of alfalfa seed significantly reduces the feeding of leaf weevils on sprouting alfalfa. No negative effects of insecticidal seed dressing on germination energy and germination were observed. On the basis of the three-year trials, the dressing insecticides Cruiser 350 FS (active ingredient thiamethoxan) and Elado 480 FS (active ingredients beta-cyfluthrin and clothianidin), both at a dose of 20 l/t, can be recommended as an effective method to protect alfalfa against leaf weevils.

Keywords: alfalfa; *Sitona* spp.; feeding of leaf weevils; artificial infestation; insecticidal seed dressing

Leaf weevils of the genus *Sitona* are snout beetles (Coleoptera: Curculionidae) that are harmful as adults to leguminous crops by feeding on leaves, while the larvae can harm the root system of the plants. Landon *et al*. (1995) emphasised that leaf weevils are a long-term cause of reduced yields of pea. Losses are caused partly by adult weevil feeding, but also by larval feeding on the root system. Leaf weevils can do serious harm to sprouting leguminous crops, especially alfalfa. The extent of damage is related to the pattern of weather conditions and the developmental stage of the crop. Leaf weevils cause the greatest damage if the weather is dry and warm and alfalfa is at the developmental stage between cotyledonous leaves and 2nd or 3rd leaf stage (Rotrekl 1979). Damage to alfalfa caused by *Sitona* larvae is described by Pisarek (2001a). The same author studied the occurrence of *Sitona* weevils on alfalfa in Poland (Pisarek 2001b). Economic thresholds for leaf weevils are known for pea and are shown e.g. in Seidenglanz (2003), but also for sprouting alfalfa (Rotrekl 1979). For the protection of sprouting plants, foliar application of insecticides or insecticidal seed dressing can be used. Yet insecticidal seed dressing is the most suitable protection for

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sprouting plants (Rotrekl & Nedělník 1992; Rotrekl 1993). Taupin and Janson (1997) and van de Steene *et al.* (1999) dealt with the protection of sprouting pea against feeding by leaf weevils. According to them, suitable dressing insecticides are products with active ingredients like imidacloprid, furathiocarb and benfuracarb which are more efficient by foliar application. The aim of our study was to determine suitable insecticidal dressing(s) and doses for the protection of sprouting alfalfa.

MATERIAL AND METHODS

The study was carried out at Troubsko near Brno (south Moravia, Czech Republic), in the fields and the greenhouses of the Research Institute for Fodder Crops, Ltd. The experimental plots were in a sugar-beet growing region at an altitude of 270 m, mean annual temperature of 8.4°C (14.8°C at the time of cultivation) and mean annual precipitation of 547 mm (of which 344 mm fall during the growing season). The soils are loamy, medium heavy, soil type brown, developed on loess, with a neutral reaction and intermediate humus content. The alfalfa cultivar Morava was used.

Feeding injury on sprouting alfalfa by beetles was evaluated in tests with artificial infestation by leaf weevils in the greenhouse and in small-plot trials with natural infestation of sprouting alfalfa in the years 2004–2006. In five treatments and four replications feeding on sprouting alfalfa in greenhouse tests with artificial infestation by leaf weevils of the genus *Sitona* was evaluated. Individual treatments represented different types and doses of insecticidal seed dressing. In the control variant undressed seed was sown, and in the standard treatment the seed was treated with insecticidal seed dressing with the active ingredient furathiocarb (Promet 400 CS at a dose of 5 l/t seed, producer Novartis Crop Protection AG). In the other variants the seed was treated with: Chinook 200 FS (active ingredients 100 g beta-cyfluthrin and 100 g imidacloprid, producer Bayer CropScience) at a dose of 10 l/t seed; Cruiser 350 FS (350 g active ingredient thiamethoxam, producer Syngenta Crop Protection AG) at doses of 10 l/t, 15 l/t and 20 l/t seed; Poncho 600 FS with 600 g the active ingredient clothianidin at a dose of 5 l/t of seed (producer Bayer CropScience); and seed dressing Elado 480 FS with active ingredients of 80 g beta-cyfluthrin + 400 g clothianidin at doses of 15 l/t and 20 l/t of seed (producer Bayer CropScience). The seed dressing was done with the laboratory seed dresser Mini Rotostat 150; either the undiluted formulation at lower doses was used or (in case of Promet 400 CS and Poncho 600 FS) it was necessary to dilute the formulation to ensure complete coverage of the small-sized alfalfa seed. At high doses, above 20 l/t, we used an absorbent (Talkum Blue) to make sure that the seed was perfectly loose. The effect of the insecticidal seed dressings on germination energy and germination was assessed in Petri dishes with filter paper in the laboratory 4 days (germination energy) and 7 days (germination) after the start of the tests.

In greenhouse tests, alfalfa was sown into containers with insulators. At the developmental stage of cotyledonous leaves, adult leaf weevils that had been collected on pea were put into the containers. Two species were present in the collections: *Sitona lineatus* L. was dominant, while the numbers of *S. macularius* (Marsham) were lower; the proportion of the two species corresponded roughly to the spectrum of *Sitona* spp. usually found on sprouting leguminous crops in the field. The number of beetles put into the containers was in all the years approximately the same – one beetle per five plants. The small-plot trials were carried out in a randomised block design, with four replications, on plots of 10 m^2 (1.25 × 8 m). The seed was sown by an Oyjord seeder at a rate of 12 kg/ha.

To assess the damage by leaf weevils on alfalfa, a scale according to loss of leaf area was used. In 2004 the plants were classified into four levels: 1 – no damage; 2 – up to 20% of the leaf area eaten; 3 – up to 50%; and 4 – more than 50% of the leaf area eaten. Since 2005, for more precise assessment, a five-level scale was used: 1 – no damage; 2 – up to 10% of the leaf area eaten; 3 – up to 25%; 4 – up to 50%; and 5 – more than 50% of the leaf area eaten. To express plant damage by one number we calculated the so-called average level of damage as the number of plants in a single level multiplied by the designation of the level, and the sum of all numbers was divided by the number of levels. As follows, we assigned the average level of damage only to damaged plants. At the end of the tests, we also assessed weight the green matter. Before the first cut, we sampled and weighed alfalfa plants from each plot (area of 2 × ¼ m^2). We expressed the yield in g/m^2. The data were processed statistically using one way ANOVA and Tukey HSD (Honest Significant Difference) test at

Table 1. Effect of insecticidal seed dressings on germination energy and germination in the years 2005 and 2006 (in %)

Variant	2005		2006	
	germination energy	germination	germination energy	germination
1. untreated control	75.0[a]	76.8[a]	94.8[a]	95.0[a]
2. Promet 400 CS (5 l/t)	72.3[a]	74.3[a]	91.5[a]	92.5[a]
3. Elado 480 FS (15 l/t)	69.5[a]	71.0[a]	90.3[a]	91.8[a]
4. Elado 480 FS (20 l/t)	77.0[a]	78.0[a]	90.8[a]	92.3[a]
5. Cruiser 350 FS (10 l/t)	70.5[a]	71.5[a]	–	–
6. Cruiser 350 FS (15 l/t)	–	–	93.8[a]	94.0[a]
7. Cruiser 350 FS (20 l/t)	–	–	92.0[a]	92.5[a]

[a]values followed by the same letter are not significantly different at the level of significance P = 0.05 (Tukey procedure)

$P \leq 0.05$ without transformation of the obtained data. The efficacy of a seed dressing was evaluated using the formula of Abbott.

RESULTS

The effects of insecticidal seed dressing and its doses on germination energy and germination in individual years are shown in Table 1. In 2005, the germination energy of individual variants ranged from 69.5% to 77.0%; the differences between treatments were statistically insignificant (F = 0.680). Similar results were found with germination; the differences between variants (from 71.0% to 78.0%) were statistically insignificant (F = 0.644). In 2006, relative germination energy (90.3%) was the lowest in the treatment with the lower dose of Elado 480 FS, and the highest (94.8%) in the untreated control; These slight differences between variants were not statistically significant (F = 1.529). Assessment of germination gave similar results; the differences between treatments (from 91.8% to 95.0%) were not statistically significant (F = 0.620).

Greenhouse tests

The results from 2004 of feeding of leaf weevils after artificial infestation of alfalfa with weevils of the genus *Sitona* are given in Table 2. In that year, the trials were assessed 2, 4 and 7 days after infestation and on a four-level scale. Undamaged plants were found only in treatments that had received

Table 2. Effect of seed dressings on feeding on sprouting alfalfa after artificial infestation with leaf weevils, Troubsko 2004

Variant	Number of plants of alfalfa damaged at one of four levels (1–4) by feeding of leaf weevils											
	1st assessment				2nd assessment				3rd assessment			
	1	2	3	4	1	2	3	4	1	2	3	4
1. untreated control	0	21	68	8	0	7	46	47	0	10	31	60
2. Promet 400 CS (5 l/t)	10	72	15	3	3	66	20	11	0	43	20	20
3. Chinook 200 FS (10 l/t)	9	82	7	2	4	65	26	5	0	40	43	17
4. Elado 480 FS (15 l/t)	45	51	4	0	29	59	11	1	7	44	38	11
5. Poncho 600 FS (5 l/t)	56	42	2	0	50	30	18	2	34	27	31	8

1st assessment – 2 days after infestation; 2nd assessment – 4 days after infestation; 3rd assessment – 7 days after infestation

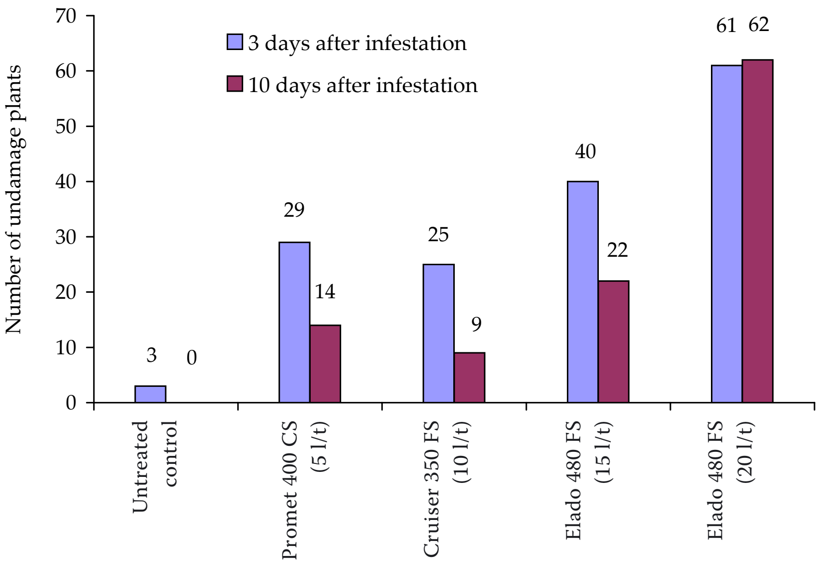

Figure 1. Effect of seed dressing on number of undamaged plants by artificial infestation of sprouting alfalfa by leaf weevils in year 2005

seed dressing. In the first assessment, treatment with Poncho 600 FS gave the best efficacy with 75%; Elado 480 FS at a dose of 15 l/t of seed had a lower efficacy at 67.9%; and Promet 400 CS had the lowest efficacy at 39.7% (F = 25.316). In the second assessment there was a highly significant difference between untreated control and treated plants (F = 17.744), and the differences between treated plants were low. Again, Poncho 600 FS and Elado 480 FS had the highest efficacy (70.0% and 65.0%).

Figures 1 and 2 show the results of 2005, when an upgraded five-level scale for assessing the damage by leaf weevils on alfalfa was used. Figure 1 shows the effect of different seed dressing on the number of undamaged plants of sprouting alfalfa 3 days and 10 days after infestation. The lowest number of undamaged plants was in the untreated control, statistically highly significantly lower than in the other variants on both dates of assessment (3 days after infestation F = 11.875, 10 days after infestation F = 5.780). The efficacy of dressing ranged from 71.1% (by Promet 400 CS, the standard) to the highest efficacy of 93.2% achieved by Elado 480 FS at the higher dose of 20 l/t of seed. Figure 2 shows the results of damage to alfalfa calculated as an average level of damage. On both dates of assessment the treatment with Elado 480 FS at a dose of 20 l/t of seed left mostly undamaged plants, this was statistically more significant than

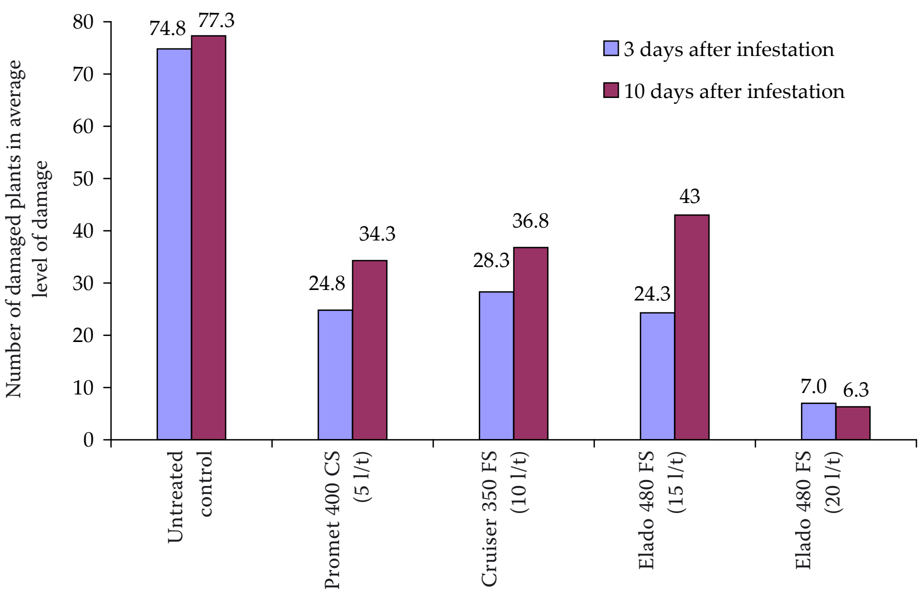

Figure 2. Effect of seed dressing on number of alfalfa plants damaged by leaf weevils in average level of damage by artificial infestation in year 2005

in the untreated variant (3 days after infestation $F = 10.888$, 10 days after infestation $F = 8.857$). A statistically significant difference between treatments was not proved.

Small-plot trials

Table 3 gives results from assessing the damage by feeding of leaf weevils on alfalfa with natural infestation. They show that also under natural conditions, seed dressing is a very effective way of protecting alfalfa from leaf weevil feeding. The efficacy of the tested seed dressings was lower than in the greenhouse tests, but the untreated controls were statistically significantly more damaged than treated plants ($F = 16.495$). The best results were obtained by treatment with Elado 480 FS at the higher dose; in the first assessment, efficacy was 68.0% and the residual efficacy was 59.7%. Treatment with Promet 400 CS (standard) had the lowest efficacy (48.5%), and its residual efficacy was only 20.8%.

Table 4 shows the results of the trials with natural infestation in 2006. The untreated control was statistically significantly more damaged than the treated plots ($F = 4.146$). There were only few undamaged plants in the whole trial; the plants from treated plots were mainly classified into the 2nd level of damage (from 47% to 70% of the plants). This is a level with only sporadic feeding without any significant damage. In contrast, the untreated control had a majority of plants classified at the 3rd, 4th and also 5th level (83.5 % of the plants). The number of plants in the treated variants was also statistically significantly higher ($F = 7.043$). The biological efficacy of the dressing was best in two of the newly tested dressings at higher doses (Cruiser 350 FS at 55.0%, and Elado

Table 3. Assessment of damage to alfalfa plants by feeding of leaf weevils after natural infestation, Troubsko 2005

Variant	Number of alfalfa plants classified into levels of damage according to feeding by leaf weevils									
	first assessment					second assessment				
	1	2	3	4	5	1	2	3	4	5
1. untreated control	0	5	15	12	8	1	17	14	5	3
2. Promet 400 CS 5 l/t	6	19	12	2	1	5	21	8	4	2
3. Cruiser 350 FS 10 l/t	2	24	14	0	0	9	26	5	0	0
4. Elado 480 FS 15 l/t	4	27	9	0	0	4	26	8	2	0
5. Elado 480 FS 20 l/t	8	31	1	0	0	12	27	1	0	0

Table 4. Levels of damage to alfalfa plants by feeding of leaf weevils after natural infestation, Troubsko 2006

Variant	Number and percentage of plants of alfalfa classified into levels of damage according to feeding by leaf weevils									
	number of plants in level					percentage of plants in level				
	1	2	3	4	5	1	2	3	4	5
1. untreated control	0	7.5	12.5	13.3	11.7	0	16.7	27.8	29.8	25.9
2. Promet 400 CS 5 l/t	0	41.7	20	8.3	0	0	59.5	28.6	11.9	0
3. Cruiser 350 FS 10 l/t	5	41.7	15	5.8	2.5	7.1	59.5	21.4	8.3	3.7
4. Cruiser 350 FS 20 l/t	5	40.8	10.8	1.7	0	8.6	70	18.5	2.8	0
5. Elado 480 FS 15 l/t	1.7	26.7	20.8	4.2	3.3	2.9	47	36.8	7.4	5.9
6. Elado 480 FS 20 l/t	2.5	60	28.3	0	0	2.8	66	31.2	0	0

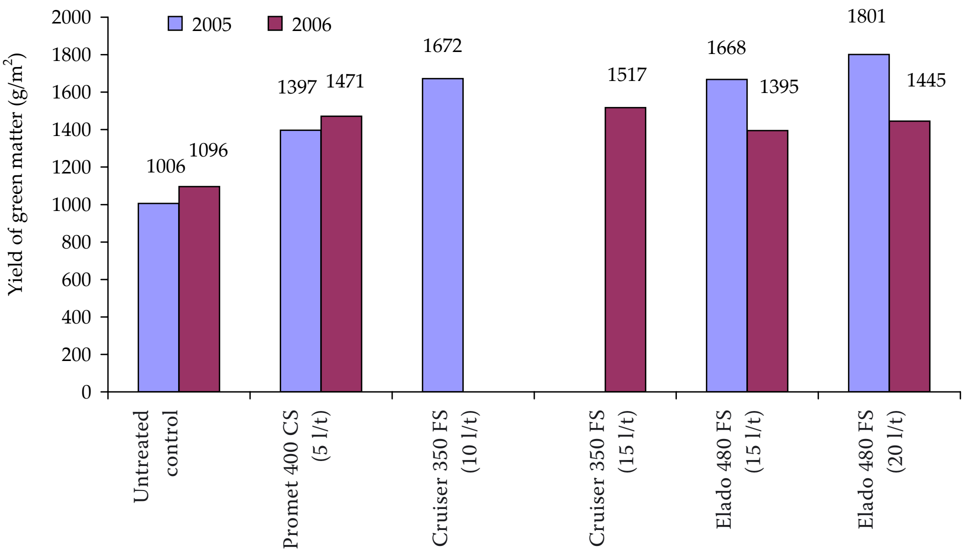

Figure 3. Effect of seed dressing on yield of green matter from the first cut in small-plot trials in years 2005 and 2006

480 FS at 52.5%). Lower doses and the standard treatment had a biological efficacy from 36.1% to 47.2%. These relatively lower values of biological efficacy are due to the fact that the dressings act through feeding and plants must be damaged. The total number of plants in a running meter of a row was significantly lower in the untreated control (on average 45 plants) than in the treated plots, where the average number of plants in a running meter of a row was between 50 (variant 4) and 90.8 (variant 6).

Green matter yields, in grams per m^2, obtained in the years 2005 and 2006 are given in Figure 3. Compared to the untreated control, green matter yield from the first cut in the year 2005 was significantly higher in all treated plots (F = 13.564) within the treatment with Promet 400 CS. This treatment compared with the control was less damaged, only at the 95% level of probability. Also in 2006, the control produced the lowest yield of green matter; though treated plants always gave higher yields, the difference was insignificant (F = 1.894).

DISCUSSION

The problem of protecting sprouting alfalfa has been studied only in a few countries, so that literary data are very sporadic. In years favourable for leaf weevil feeding, damage to sprouting alfalfa in the Czech Republic is significant (Rotrekl 1979). For protection in the Czech Republic, insecticidal seed dressing with the active ingredient furathiocarb (Rotrekl & Nedělník 1992) has been used. In foreign countries, protection against leaf weevils is studied mainly in other leguminous crops, chiefly pea (van de Steene *et al*. 1999). Pisarek (2001a, b) described the occurrence of leaf weevils and their damage to alfalfa, but did not deal with the protection against this insect. Since use of the dressing Promet 400 CS (active ingredient furathiocarb) has been restricted, alfalfa could no longer be protected against leaf weevils in the Czech Republic. Furthermore, nobody in this country studies this problem. Our efforts over the last years were to gain knowledge of how to protect alfalfa against leaf weevils. The results obtained in the present study are intended to be tranferred for use in agricultural practice.

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