Attractant-baited traps for the sugar-beet weevil *Bothynoderes (Cleonus)* punctiventris: Preliminary study of application potential for mass trapping

I. Tomaseva, I. Sivcevb, I. Ujváryc, M. Tóthd,*

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**Abstract**

The sugar-beet weevil (*Bothynoderes punctiventris* Germar) (Coleoptera: Curculionidae) is one of the most important insect pests of sugar-beet throughout central, eastern and southeastern parts of Europe. The damage by the overwintering adult beetles is caused by feeding on sugar-beet seedlings in early spring. As a possible alternative to insecticides, the present research was aimed at studying the potential of traps baited with a synthetic aggregation attractant in decreasing the population of the sugar-beet weevil through mass trapping at the overwintering sites.

It was demonstrated that by setting out traps baited with a blend of synthetic \((Z)\)- and \((E)\)-2-ochtodenal [=Grandlure III–IV; \((Z)\)- and \((E)\)-(3,3-dimethyl)cyclohexylidene)acetaldehyde; the aggregation attractant] at 10 and 30 trap/ha densities, 30–100% of the sugar-beet weevil population was mass-trapped at the overwintering sites. Traps caught non-target beneficial insects in very low numbers. Application of the traps shows good potential as a control method especially at population densities of 30 000 insect/ha or below, and may be capable of decreasing the population pressure of immigrating beetles to sites where sugar-beet is planted in the spring.

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**Keywords:** *Bothynoderes (Cleonus) punctiventris*; Coleoptera; Curculionidae; Aggregation attractant; Mass trapping

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**1. Introduction**

The possibility of direct control through mass trapping with pheromone or attractant-baited traps has long intrigued both scientists and crop protection experts. Mass trapping offers promising perspectives with beetle pests, where aggregation pheromones are frequently found (Francke and Dettner, 2005). In comparison to the widely used pheromone traps for moth spp., in this case, the impact of traps reducing the population should be larger since the traps are capturing both sexes. Also, in many coleopteran pests the damage-causing life stage is the adult, so the traps, by removing a—hopefully—large part of the population, may decrease damage directly.

The sugar-beet weevil (*Bothynoderes punctiventris* Germar) (Coleoptera: Curculionidae) is an important pest of sugar-beet throughout central, eastern and southeastern parts of Europe (Hoffmann, 1966; Manninger, 1990). Both the adults and the larvae cause damage. Overwintering adult beetles cause damage by feeding on sugar-beet seedlings. In the areas with drier climate the weevil represents the most destructive insect pest of sugar-beet causing severe losses especially during outbreak periods frequently on up to 50% of fields. During the 20th century *B. punctiventris* has destroyed ca 2 m ha of sugar-beet fields in eastern Europe (Camprag, 1992; Sekulic et al., 1997a). This represents the loss of ca 12.800.000 ton of sugar which at present has a market value of 8.32 billion Euros.

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*Corresponding author. Tel.: +36 1 3918639; fax +36 1 3918655. E-mail address: h2371tot@ella.hu (M. Tóth).
Control of the adult weevil heavily depends on the use of significant amounts of insecticides. In Yugoslavia during 26 years of chlorinated hydrocarbon insecticide usage (until their final ban in 1972), ca. 12 000 ton were applied to control sugar-beet pests (Camprag, 1992). Out of a total of 27 kg/ha pesticide use, 17 kg were insecticides to control the sugar-beet weevil, while in other field crops, which are not attacked by the weevil (i.e. wheat, maize, sunflower, etc.), up to 90% less insecticides were required (Markovic, 1988).

In recent years foliar applications of monocrotophos, fenitrothion, chlorpyrifos and fenithion were mostly used (Sekulic et al., 1997b). These were banned in 2003 in the European Community, and starting from 2007 they will also be banned in Serbia (Anonymous, 2002).

Another problem of using insecticide sprays for control of the adult weevil in early spring is that if the treatment is not applied in warm sunny weather, a large proportion of the weevils are unaffected, since they remain hidden in the upper layer of soil in unfavourable weather.

Recently a powerful synthetic attractant has been described for the sugar-beet weevil (Tóth et al., 2002a, b, 2007). Pitfall traps baited with the attractant catch both female and male weevils (Tóth et al., 2002a, b, 2007). Reducing the adult weevil populations through mass trapping would present a new method of control, and at the same time would fulfill perfectly the requirements of an integrated pest management system.

However, an attractant which is suitable for detection and monitoring may not be powerful enough for use in mass trapping. Consequently as a first step in the development of this method, it should be investigated, whether traps baited with the attractant are capable of trapping a sizeable proportion of the weevils on the given field, leading to a significant decrease in population density.

Basically there are two key points where mass trapping could be used to reduce adult weevil populations. The first is to try to trap out a significant percentage of the overwintering weevils by mass trapping the emerging beetles at the overwintering sites (“old” sugar-beet fields), and the second is to try to intercept beetles which emerged elsewhere when they arrive at the sugar-beet fields with beet seedlings (“new” fields).

According to Sekulic et al. (1997b), basic control of sugar-beet weevil should be done at the overwintering sites. In fact, the importance of this control approach was realised in affected countries a long time ago and was even regulated by law as early as in 1894 (Jablonowsky, 1913). At present farmers in the area make enormous efforts to reduce weevil populations at the overwintering sites by insecticide sprayings or digging catch trenches along the edges of “old” sugar-beet fields (I. Sivcev, personal communication).

The objective of the present research was to evaluate the potential of traps baited with the attractant in reducing the population of the sugar-beet weevil through mass trapping at the overwintering sites. If the attractant-baited traps are capable of trapping out a significant percentage of the population at overwintering sites, population pressure by immigrating weevils to “new” fields where sugar-beet is freshly planted in the spring should also diminish.

Weevils do not cause damage at the “old” sugar-beet fields where they emerge (because there are no beet seedlings there in the spring), consequently it was not possible to perform damage measurements when evaluating the effect of our mass trapping trials. At “new” sugar-beet fields, which are at more or less considerable distance from “old” fields and where the damage occurs on seedlings, it is difficult to prove that weevils causing the damage were coming from the overwintering site with mass trapping, or from another overwintering site. Consequently our studies at the “old” sugar-beet fields were restricted to establishing the proportion of emerging weevils “trapped out” as compared to the population density at the given test plot.

2. Materials and methods

2.1. Traps

Plastic buckets (25 cm high, 25 cm wide at opening, 20 cm wide at bottom, 101 capacity) were used as pitfall traps. Catch capacity of such a trap can be estimated at 8–9000 beetles without becoming saturated. In the course of our tests maximal catches of a single trap never exceeded 3000 weevils between inspection dates. The bait dispensers with the synthetic attractant were placed on a wooden stick fixed to the ground through a hole in the middle of the bottom of the bucket. Also, there were 5 holes (2–3 mm diameter) bored in the bottom part serving as outlets for the water from rain. As a killing agent 30–50 g of granules of Counter G 5 (active ingredient terbufos 5%) were placed in each trap. The granules were renewed after rain or when captured insects or mud totally covered the granules.

2.2. Attractant baits

A 1:1 mixture of (Z)- and (E)-2-octodonal [=Grandlure III–IV; (Z)- and (E)-(3,3-dimethyl)cyclohexylidene acetaldehyde] was purchased from Bedoukian Inc. (Danbury, USA). The overall purity of the sample was >99% by GC.

Rubber dispensers were prepared by using pieces of rubber tubing (Taurus, Budapest, HG; No. MSZ 9691/6; extracted 3 times in boiling ethanol for 10 min, then also 3 times in methylene chloride overnight). The rubber dispensers were attached to 8×1 cm pieces of plastic sheet for easier handling when assembling the traps.

For making up the baits, 500 μg of the 1:1 mixture of (Z)- and (E)-2-octodonal (Grandlure III–IV) was administered to the surface of the rubber dispensers in hexane solutions. After having allowed the solvent to evaporate, dispensers were wrapped singly in pieces of aluminum foil and were stored below –10 °C until use.
2.3. Field tests

Tests were conducted at sites in the Republic of Serbia. Trapping tests were performed at overwintering sites of the sugar-beet weevil, in fields where sugar-beet had been cultivated the previous year.

In each year, 8 plots of 1 ha each (squares of 100 × 100 m) were selected (leaving a 15 m wide corridor around each plot for isolation). On 4 of these 40 traps were set up (giving a density of 10 trap/ha). On the 4 other plots a total of 120 baited traps were set up (30 traps/ha). In the middle portion of all 8 plots 5 buckets without attractant bait (unbaited traps) were also set up, in order to have an independent measure of weevil density and sex ratio in the given plot, and to cross-check attractive activity of baited traps. In these buckets weevils could only get caught by their random wandering at the soil surface.

Layout of traps is shown in Fig. 1.

Field tests were conducted at Zarkovci, from March 24–April 13, 2000 and at Bajmok, from March 31–April 15, 2004. Traps were inspected and insects caught were removed and counted at 3 day intervals during the tests.

For assessing population density of the overwintering population the standard soil sampling method was used, except that instead of one sample per ha as suggested (Camprag, 1983; Manninger, 1967) we collected 5 samples (digging holes of 50 × 50 × 50 cm) per plot giving a total of 40 samples, for better accuracy.

Tests were terminated when first flying beetles were visually recorded in the area, as such specimens may have come from outside of the plots, and thus their presence could increase the population density as compared to the values calculated from soil samplings on the given plot (which give values on overwintering specimens inside the plot only). Visual observations were done each day when weather was sunny without wind and temperatures were higher than 19 °C, as adults can fly only in such conditions (Hoffmann, 1966, Manninger, 1990).

Soon after the tests were ended farmers started to plough and sow (in most cases cereals) which destroyed part of remaining weevils, and delayed the emergence of remaining specimens from the soil. Generally it is presumed that migration from overwintering sites is practically of less importance after spring cereal sowing (Camprag, 1992; Manninger, 1990).

3. Results

In 2000 the size of population was estimated to be similar (ca 30000 insect/ha) by soil sampling at both the 10 and 30 trap/ha densities (Table 1A), and this was also confirmed by similar mean numbers caught in the unbaited control traps at sites with both trap densities (Table 1A).

A total of 48910 and 124 959 weevils were caught by attractant-baited traps at the 10 and 30 trap/ha densities, respectively. The average number caught per plot was significantly higher at the 30 trap/ha density (Table 1A).
The mean percentages of weevils “trapped out” were not significantly different between the two trap densities (Table 1A).

In 2004 the population size was again similar at both trap densities both as estimated by soil sampling (Table 1B) or based on mean catches in unbaited control traps (Table 1B). The estimated population size was ca 3 times higher than in year 2000 (Table 1).

Total numbers of weevils caught were 79,602 and 157,539 at the 10 or 30 trap/ha densities, respectively. Again there was no significant difference between mean percentages “trapped out” at the 10 or 30 trap/ha densities, and these percentages accounted for 26.9% and 39.9% of the estimated population (for 10 and 30 trap/ha, respectively) (Table 1B).

Mean catch/trap in traps baited with the attractant at the 10 or 30 trap/ha densities was similar in 2000; however, in 2004 traps at the 30 trap/ha density caught significantly less (Table 1).

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In both years and trap densities traps with attractant bait caught 4–13 times more than unbaited control traps (Table 1; P values ranging from 0.0003 to <0.0001), clearly confirming attraction by the synthetic bait (Tóth et al., 2002a, b, 2007).

Sex ratio of weevils caught generally showed male dominance in both years (Table 2). There was no significant difference in sex ratio in catches by traps with attractant, unbaited control traps or soil samples (Table 2).

The number of non-target arthropods in attractant-baited traps ranged from 3.6 to 5.3 (mean/trap) and was negligible compared to the number of weevils caught. Non-target arthropods mostly consisted of carabids, click beetles, spiders and other insects frequently found in soil-level pitfall traps.

4. Discussion

Mass trapping with pheromone-baited traps has been successfully attempted in the family of weevils before. In cotton, mass trapping with traps baited with an aggregation pheromone successfully reduced small overwintering populations of the boll weevil Anthonomus grandis.

<table>
<thead>
<tr>
<th>Density of traps</th>
<th>Mean no. of weevils caught/plot (±SE)</th>
<th>Mean no. of weevils/ha estimated (based on soil sampling) (±SE)</th>
<th>Mean % of weevils trapped out as compared to estimated no./ha (±SE)</th>
<th>Mean no. of weevils caught/trap (±SE)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>In attractant-baited traps</td>
<td>In traps with no attractant</td>
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</tbody>
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Table 1
Mean no. of B. punctiventris weevils captured per plot, estimated population density and percentage of weevils “trapped out” by attractant-baited traps, and mean no. caught per trap in attractant-baited vs. control traps with no attractant in tests at overwintering sites in 2000 and 2004

<table>
<thead>
<tr>
<th>Density of traps</th>
<th>Trap density</th>
<th>Mean % of females (±SE)*</th>
<th>Traps with attractant</th>
<th>Unbaited traps</th>
<th>Soil samples</th>
<th>P value (ANOVA)</th>
</tr>
</thead>
</table>

Table 2
Sex ratio of B. punctiventris weevils caught in baited or unbaited traps and in soil samples

*Numbers in brackets show total number of weevils sexed.

P values derived from ANOVA.
Boheman. (Coleoptera, Curculionidae) (Hardee, 1982).
The population density of sweet potato weevils *Cylas formicarius* Fabr. (Coleoptera, Brentidae) was notably decreased in a field with pheromone baited traps (Yasuda, 1995). In the palm weevil *Rhynchophorus palmarum* L. (Coleoptera, Curculionidae), a pheromone-based mass trapping system was capable of changing the distribution of weevils in the plantation, and decreased the incidence of red ring disease caused by the nematode *Bursaphelenchus cocophilus* Cobb., which is transmitted through the weevils (Oehlschlager et al., 1995).

In the present study mean catches per plot were 2–3 times higher in the 30 trap/ha than in 10 trap/ha density treatments. This suggests that a density of traps between 10 and 30 trap/ha may be favourable for efficient mass trapping, though the cost of application of more traps/ha may become prohibitive.

The mean catch per trap in year 2000 was similar, suggesting that, for each trapping density there was no significant interference between traps. In 2004, however, the mean catch per trap was by ca. 30% lower in the 30 trap/ha density plots. This trend may indicate the beginning of interference between adjacent traps, so probably the application of traps at higher densities than 30 trap/ha cannot be advised.

In tests at overwintering sites in this study sizeable proportions of the (estimated) sugar-beet weevil populations were “trapped out” in both years. Percentages of “trapped out” weevils were especially striking in 2000, when population density was ca. 30000 insects/ha (one-third of that in 2004). In 2004 still ca 30–40% of the estimated population was “trapped out”.

Removal of masses of weevils at the amounts recorded in our tests is probably of advantage in reducing pest pressure on “new” beet fields. Damage threshold for sugar-beet weevils is 0.1 insects/m² during emergence of beet seedlings (Sekulic et al., 1997a). So for example the amount of 31240 weevils/ha trapped out (30 trap/ha density, year 2000) would have the potential in theory to maintain damage threshold over an area of 31 ha. These weevils were trapped and destroyed already at emergence, much earlier and some distance away from the fields with beet seedlings where actual damage is caused.

Mean percentages of weevils “trapped out” in both years showed a tendency of being slightly higher at 30 trap/ha densities (although the difference was not significant), which again suggests that better mass trapping efficiency can be expected from a density of traps higher than 10 trap/ha; however, probably no further dramatic increase can be expected when using higher trap densities than 30 trap/ha.

An additional advantage of the present attractant-baited traps for mass trapping was that they showed considerable specificity in catching the sugar-beet weevil and caught non-target, in part beneficial insects in very low percentages as compared to the masses of weevils caught. This is one of the basic requirements expected of a trap type to be used for mass trapping (Bakke and Lie, 1989).

In conclusion, in the present study it was demonstrated that application of traps baited with a blend of synthetic (Z)- and (E)-2-ochtodenal (the aggregation attractant) showed good potential as a control method especially at population densities of 30 000 insect/ha or below.

According to a 36-year long survey between 1961 and 1996 (Sekulic et al., 1997a), in Serbia, mean population density of overwintering weevils was up to 20 000 beetles/ha in 18 years (50%) and in 7 years (20%) it was between 20 0000–40 000 beetles/ha. According to the results of the recent study, very high proportions of weevil populations could have been “trapped out” at the overwintering sites in these years, and supplementary control measures should have been added only in the remaining 11 years (30%), when the population density was higher. Mass trapping trials with similar methods as in this study and aimed at intercepting immigrating beetles at “new” sugar-beet fields are underway and appear to give promising results (to be published in detail elsewhere).

Acknowledgement

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References


