Зборник Матице српске за природне науке / Proc. Nat. Sci, Matica Srpska Novi Sad, № 110, 195—204, 2006

UDC 633.63:631.53.02]:632.951(497.113 Bačka)"2001/2004"

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# CONTROL OF SUGAR BEET PESTS AT EARLY SEASON BY SEED TREATMENT WITH INSECTICIDES*

ABSTRACT: In the period 2001—2004, experiments were conducted in the region of Bačka (northern Serbia) to assess the efficiency of insecticide treatment of sugar beet seeds in controlling soil pests (larvae of *Elateridae* family) and reducing the damage caused by beet weevil (*Bothynoderes punctiventris* Germ.) and flea beetle (*Chaetocnema tibialis* Illig.). Several insecticides, mostly systemic ones (carbofuran, thiamethoxam, fipronil, imidacloprid and clothianidin), and their combinations with pyrethroids in different doses were tested in field conditions. Stand density, percentages of plants damaged by *B. punctiventris* and *C. tibialis*, injury level and weight of juvenile plants served as parameters for evaluation of insecticide efficiency. Most of the insecticides applied to seeds provided a significantly better stand density compared with the untreated control. Because of their systemic action, imidacloprid, thiamethoxam and their mixtures with pyrethroids provided very good protection of juvenile plants from *C. tibialis* and in some cases from *B. punctiventris*.

KEY WORDS: sugar beet, insecticides, seed treatment, wireworms (*Elateridae*), sugar beet weevil (*Bothynoderes punctiventris* Germ.), flea beetle (*Chaetocnema tibialis* Illig.)

## INTRODUCTION

Under the conditions of southeastern Europe including our country, a large number of harmful insects occur during initial stages of sugar beet development (from germination and emergence to the development of 2—4 pairs of permanent leaves). Their occurrence is the key factor of stability in sugar beet production. Among the pests of underground plant parts, click beetle and cha-

* The paper was presented at the first scientific meeting IV INTERNATIONAL SYMPOSIUM ON SUGAR BEET Protection held from 26—28 september 2005 in Novi Sad.

fer larvae (*Elateridae* and *Scarabaeidae* families) are distinguished for their economic importance. For last ten or so years in Serbia, soil pests, primarily wireworms have been controlled at about 80% of a total sugar beet acreage of about 60,000 hectares. Newly emerged sugar beet crops are threatened by numerous coleopterans, especially beet weevil (*Bothynoderes punctiventris* G e r m.), weevil (*Psalidium maxillosum* F.), gray corn weevil (*Tanymecus dilaticollis* G y l l.), flea beetle (*Chaetocnema tibialis* I l l i g.) and other species that occurred in some years. These pests are frequently the cause of thin crop stands and replanting at large areas (Č a m p r a g, 2000).

In spite of attempts to introduce integrated management of the above mentioned pests, which implies the combining of all available measures in time and space (agrotechnical, mechanical, biological etc.), chemical measures still hold the dominant place. However, more and more stringent requirements regarding the economy of crop production and environmental protection impose the need of introducing less costly and ecologically more selective methods of insecticide application, such as seed treatment during processing or before planting.

This paper reviews the results of experiments undertaken to assess the efficiency of sugar beet seed insecticide treatment in the control of wireworms (the larvae of *Elateridae* family), beet weevil (*Bothynoderes punctiventris*) and flea beetle (*Chaetocnema tibialis*).

## MATERIAL AND METHOD

In the period 2001—2004, in several locations in the region of Bačka (northern Serbia), on the calcareous chernozem soil, we assessed the efficiency of seed treatment with insecticides in controlling soil pests and pests that attack sugar beets at the beginning of growing season. Sugar beet seed treatment (mostly encrusted seeds, except for 2003, when pelleted seeds were used) was performed immediately before planting, in the seed processing facilities of Institute of Field and Vegetable Crops in Novi Sad.

The experiments included the following insecticides: thiamethoxam (at the doses of 2 l/100 kg of seeds and 15, 20, 30, 45 and 60 g active substance (a.s.)/seed unit (s.u.), imidacloprid (at the doses of 25, 50 and 90 g a.s./s.u.), fipronil (at the doses of 80 and 100 ml a.s./s.u.), carbofuran (at the doses of 30 g a.s./s.u. and 3 and 4 l/100 kg seeds), tefluthrin (at the doses of 8 g a.s./s.u. and 5.0 kg/ha) and clothianidin (at the dose of 68 g a.s./s.u.), the mixtures thiamethoxam + tefluthrin (15 + 6, 15 + 8, 60 + 4 and 60 + 8 g/s.u.), imidacloprid + beta-cyfluthrin (15 + 8, 45 + 6 and 60 + 8 g a.s./s.u.), imidacloprid + tefluthrin (15 + 4 g a.s./s.u.), imidacloprid + pencycuron (100 ml a.s./s.u.), carbofuran + bifenthrin (2.0 + 0.2 l/100 kg seeds) and a granulated insecticide terbufos (at the dose of 25 kg/ha).

The experiments were conducted in the field, usually in small plot trials (large plot trials were used only in the first two years in the location of Kljajićevo), in a block design with four replications, with the basic experimental unit size of 20—30 m$^2$ (4—6 rows 8—10 meters long). The experiment plots were mostly machine-planted (except in the location Aleksa Šantić, where planting was performed manually), at the optimum date (March 19—29), in the spacing from 50 x 6 cm to 50 x 18 cm (in different years and locations).

The efficiency of the applied insecticides was evaluated via the following parameters: the achieved stand density, percentages of plants damaged by *B. punctiventris* and *C. tibialis*, injury level caused by *C. tibialis* and weight of juvenile plants. The results were mostly expressed in relative values.

## RESULTS

The effect of the tested insecticides varied depending on the pest population density and weather conditions during the study period.

The effect of seed treatment on soil pests and *B. punctiventris*. In the first year of study (2001), better protection of crop stand from the soil pests was achieved in the location A. Šantić than in the location Kljajićevo. The first location had a higher density of wireworm larvae from *Agriotes* genus than the second one (14.0/$m^2$ and 3.2/$m^2$, respectively). In A. Šantić, stand density was higher comparing to the control (in the second, final evaluation) from 15—19% in the case of thiamethoxam to 36—46% in the cases of imidacloprid and its mixtures with tefluthrin and beta-cyfluthrin (Table 1). The case was reversed with *B. punctiventris*. Its occurrence was lower in the first location (only 15.5% slightly damaged plants in the control) and the efficiency of insecticides was proportionally lower. In the location Kljajićevo, all control plants were intensively damaged by *B. punctiventris*. The lowest percentage of damaged plants (26—30%), with very low intensity of damage was achieved with thiamethoxam (60 g a.s./s.u.) and imidacloprid (90 g a.s./s.u.).

Table 1. The effects of seed treatments by insecticides against wireworms (*Elateridae*) and sugar beet weevil (*Bothynoderes punctiventris* Germ.) in sugar beet crops, expressed through relative stand density and percentage of damaged plants in 2001

| Active substance | Amount of active substance (g, ml/unit) | Relative crop stand (%) | | Percentage of plants damaged[a)] by *B. punctiventris* (%) | |
|---|---|---|---|---|---|
| | | A. Šantić | Kljajićevo | A. Šantić | Kljajićevo |
| Carbofuran | 30 | 98.7 | 98.2 | 9.5 | 42.0* |
| Thiamethoxam | 45 | 115.1 | 102.0 | 14.6 | 70.0* |
| Thiamethoxam | 60 | 119.2 | 116.8 | 12.7 | 26.0 |
| Imidacloprid | 90 | 144.8 | 113.0 | 10.7 | 30.0 |
| Imidacloprid + tefluthrin | 15 + 4 | 146.1 | 99.3 | 14.7 | 94.0** |
| Imidacloprid + betacyfluthrin | 15 + 8 | 136.5 | — | 7.1 | — |
| Imidacloprid + betacyfluthrin | 45 + 6 | 145.9 | — | 8.7 | — |
| Imidacloprid + betacyfluthrin | 60 + 8 | 143.1 | — | 9.9 | — |
| Control | — | 100.0 | 100.0 | 15.5 | 100.0*** |

[a)] Damage extent from *B. punctiventris*: — very low, * low, ** medium, *** high

In the second year of study (2002), although the density of wireworm larvae in the soil (6.0 and 8.4/m$^2$) was similar in the respective locations, results were similar to previous year regarding the maintenance of stand density and the degree of plant damage by *B. punctiventris* (Table 2). In the location A. Šantić, insecticides exhibited high efficiency regarding the control of soil pests, i.e. the maintenance of stand density, with the percentages from 18.6% in the case of carbofuran to about 31% in the cases of fipronil (100 ml/s.u.) and terbufos. The occurrence of *B. punctiventris* in that location was low (only 14.2% of slightly damaged plants in the control) and the activity of insecticides was modest. In the location Kljajićevo, the control had about 30% of plants slightly damaged by *B. punctiventris*. The lowest percentages of damaged plants (5—8%), together with low intensities of damage were achieved with the application of terbufos, thiamethoxam and fipronil (100 ml a.s./s.u.).

Table 2. The effect of seed treatments by insecticides against wireworms (*Elateridae*) and sugar beet weevil (*Bothynoderes punctiventris* G e r m.) in sugar beet crops, expressed through relative stand density and percentage of damaged plants in 2002

| Active substance | Amount of active substance (g, ml/unit) | Relative crop stand (%) | | Percentage of plants damaged[a)] by *B. punctiventris* (%) | |
|---|---|---|---|---|---|
| | | A. Šantić | Kljajićevo | A. Šantić | Kljajićevo |
| Carbofuran | 3.0 l/100 kg seed | 118.6 | 62.2 | 10.0 | 16.2 |
| Thiamethoxam | 2.0 l/100 kg seed | 123.1 | 71.2 | 9.8 | 7.2 |
| Fipronil | 100 | 130.2 | 95.8 | 11.7 | 8.1 |
| Fipronil | 80 | 124.8 | — | 12.5 | — |
| Imidacloprid + pencycuron | 100 | 128.4 | — | 11.0 | — |
| Terbufos | 25.0 kg/ha | 130.7 | 92.8 | 10.6 | 5.3 |
| Control | — | 118.6 | 100.0 | 14.2 | 29.6 |

a) Damage extent from *B. punctiventris*: A. Šantić — very low, Kljajićevo — low

In the third year of study (2003), in the conditions of an extremely dry spring, all preparations and mixtures exhibited highly positive effects regarding the protection of crop stand against soil pests in all three locations (Figure 1). The effect was the highest in A. Šantić, where the population density of wireworms was also the highest (14.7 individuals/m$^2$). Compared to the control, the stands were from 63% higher in the plots with mixture of imidacloprid and tefluthrin to 98—116% in the case of the mixtures of thiamethoxam and tefluthrin (the percentage increasing in proportion with the dose). In the location of Sombor (7.2 individuals/m$^2$) the stands were higher from 21% (tefluthrin) to 77% (thiamethoxam) in relation to the control. In the location R. Šančevi (6.3 individuals/m$^2$), the efficiency was somewhat lower than in the first two locations and it was at the same significance level as the treated crop stands in relation to the control and the stands were from 25% higher in the case of thiamethoxam to 34% in the case of the medium dose of the mixture of thiamethoxam and tefluthrin.

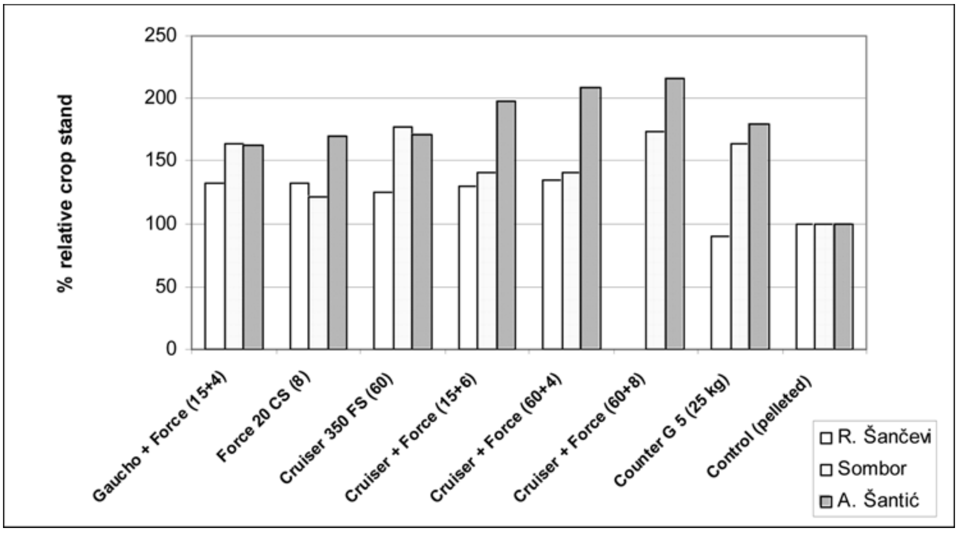


Fig. 1. The effect of seed treatment by insecticides against wireworms (*Elateridae*) in sugar beet crops, expressed through relative stand density in 2003

In the last year of study (2004), which was characterized by considerably lower density of the wireworm population in the soil and abundant rainfall in April and May, which postponed the emergence and growth of plants while accelerating the degradation and leaching of the applied insecticides, the efficiency of the insecticides in the protection of crop stand was much lower (Figure 2) than in the previous years, especially in the location of R. Šančevi. In the location A. Šantić, which had the highest density of wireworms (2.7 individu-

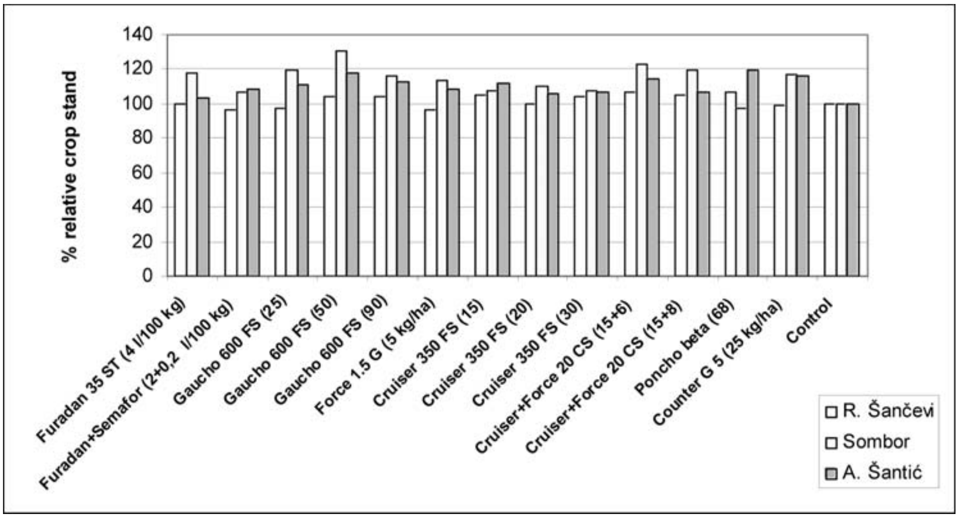


Fig. 2. The effect of seed treatment by insecticides against wireworms (*Elateridae*) in sugar beet crops, expressed through relative stand density in 2004

als/m$^2$), crop density was from 3.1—8.6% higher than in the control in the cases of carbofuran, its mixture with bifenthrin, the two higher doses of thiamethoxam and the higher dose of its mixture with tefluthrin to 11.3—19.6% (the highest percentage was obtained with clothianidin). In the location of Sombor (1.6 larvae/m$^2$), the stand was from 6.3% higher (in the case of carbofuran + bifenthrin) to 30.2% (in the case of imidacloprid, 50 g a.s./s.u.).

In 2003 and 2004, the occurrence of *B. punctiventris* in the examined locations was either very low or very intensive (when foliar treatments had to be performed), so that it was not possible to make valid estimates of the activity of the applied insecticides.

*The effect of seed treatment on beet flea beetle*. The occurrence of *C. tibialis* was intensive in 2001 and 2003 and medium in 2004. As the occurrence of the pest was limited to the location of R. Šančevi, insecticide efficiency was assessed only in that location. As the results from 2001 and the part of 2003 experiments had already been reported, this paper deals only with the results from the last two years.

On 8 May 2003, about 40 days after planting, 25 plants were sampled from each experiment unit (i.e. 100 plants per treatment), at the phenophase of 2—3 pairs of permanent leaves and assessed in laboratory for the intensity of damage by beet flea beetles and measured for plant weight. In the conditions of high population density of beet flea beetles, high air temperatures (maximum daily temperatures ranging between 28 and 32°C) and exceptionally low rainfall (8 mm in April and 9 mm in May), practically all plants were damaged but with various levels of damage intensity (according to the scale of Sekulić et al., 2002). In the control and the treatment with terbufos (Table 3), there were no slightly damaged plants (1—10 holes per plant), 12% and 15% of plants, respectively, were medium damaged (11—50 holes per plant) and 88% and 85% of plants, respectively, were intensively damaged (over 50 holes per plant). The treatment with tefluthrin provided poor control of beet flea beetles (5% slight damage, 33% medium damage and 62% intensively damaged plants). However, tefluthrin mixture with imidacloprid, and especially with thiamethoxam provided very good control of beet flea beetles (75—97% respectively slight damage, 4—15% medium damage and only 0.8—14% intensively damaged plants).

Table 3. The effect of seed treatment by insecticides on young plants weight of sugar beet and injury level from *Chaetocnema tibialis* (Rimski Šančevi, 2003)

| Active substance | Amount of active substance (g, ml/unit) | Young plants weight (g) | % of plants with different injury level from *C. tibialis* | | | |
|---|---|---|---|---|---|---|
| | | | no injuries | low | medium | high |
| Imidacloprid + tefluthrin | 15 + 4 | 71.8 | 0.0 | 75.0 | 11.0 | 14.0 |
| Tefluthrin | 8 | 43.0 | 0.0 | 5.0 | 33.0 | 62.0 |
| Thiamethoxam | 60 | 65.8 | 0.0 | 96.8 | 3.2 | 0.0 |
| Thiamethoxam + tefluthrin | 15 + 6 | 75.8 | 0.0 | 84.0 | 15.2 | 0.8 |
| Thiamethoxam + tefluthrin | 60 + 4 | 77.6 | 0.0 | 96.0 | 4.0 | 0.0 |
| Terbufos | 25.0 kg/ha | 30.9 | 0.0 | 0.0 | 15.0 | 85.0 |
| Control | — | 23.0 | 0.0 | 0.0 | 12.0 | 88.0 |

The weight of 25 young plants was the largest (71.8—77.6 g) with plants that emerged from seeds treated with mixtures of the insecticides imidacloprid and thiamethoxam with the pyrethroid tefluthrin. The weight was slightly smaller (65.8 g) with the treatment of thiamethoxam alone. Significantly lower weights were obtained with tefluthrin and terbufos (43.0 and 30.9 g, respectively) and in the control (only 23.0 g).

During the second assessment in 2004, about 50 days after planting (20 May), 100-plant samples were examined in the laboratory at the phenophase of 2—3 pairs of permanent leaves and the same parameters were assessed as in the previous year. The percentage of damaged plants from *C. tibialis* was very high in all treatments and control (62.5—98.4%), but damage extent was very different (Table 4). Almost all insecticides provided high percentages of slightly damaged plants (31.7—74.2%), low portions of medium damaged plants (1.71—39.2%) and the lowest portions of intensively damaged plants (0—21.7%).

Table 4. The effect of seed treatment by insecticides on young plants weight of sugar beet and injury level from *Chaetocnema tibialis* (Rimski Šančevi, 2004)

| Active substance | Amount of active substance (g, ml/unit) | Young plants weight (g) | % of plants with different injury level from *C. tibialis* | | | |
|---|---|---|---|---|---|---|
| | | | no injuries | low | medium | high |
| Carbofuran | 4.0 l/100 kg seed | 32.2 | 1.6 | 74.2 | 21.7 | 2.5 |
| Carbofuran + bifenthrin | 2.0 + 0.2/100 kg seed | 30.2 | 11.7 | 31.7 | 35.0 | 21.6 |
| Imidacloprid | 25 | 36.8 | 2.5 | 56.6 | 39.2 | 1.7 |
| Imidacloprid | 50 | 45.4 | 12.5 | 73.3 | 14.2 | 0.0 |
| Imidacloprid | 90 | 39.7 | 37.5 | 60.8 | 1.7 | 0.0 |
| Tefluthrin | 5.0 kg/ha | 35.9 | 8.3 | 55.0 | 35.9 | 0.8 |
| Thiamethoxam | 15 | 34.3 | 7.5 | 73.3 | 16.7 | 2.5 |
| Thiamethoxam | 20 | 38.1 | 20.8 | 53.3 | 25.9 | 0.0 |
| Thiamethoxam | 30 | 37.0 | 26.7 | 43.3 | 8.3 | 21.7 |
| Thiamethoxam + tefluthrin | 15 + 6 | 41.8 | 26.6 | 55.0 | 9.2 | 9.2 |
| Thiamethoxam + tefluthrin | 15 + 8 | 38.8 | 26.7 | 70.0 | 3.3 | 0.0 |
| Clothianidin | 68 | 35.7 | 28.3 | 61.7 | 9.2 | 0.8 |
| Terbufos | 25.0 kg/ha | 23.7 | 2.5 | 74.2 | 23.3 | 0.0 |
| Control | — | 23.0 | 2.5 | 33.3 | 50.9 | 13.3 |

The weight of 25 juvenile plants was the highest in the plants that emerged from the seeds treated with imidacloprid (37—45.4 g) and mixtures of thiamethoxam and tefluthrin (38.8—41.8 g). Slightly lower values (34.3—38.1 g) were achieved with thiamethoxam applied alone, clothianidin and granulated tefluthrin. Significantly lower values were achieved with terbufos (23.7 g) and in the control variant (23.0 g).

## DISCUSSION

When referring to seed treatment with insecticides, one has in mind primarily plant protection against soil-dwelling pests, but also a complete or partial protection of scant foliage of the young plants from different weevils, flea beetles and other pests which attack sugar beets at the beginning of growing season. Sugar beet seed treatment is performed more frequently than it is the case with other crops. In 18 countries of West Europe, insecticide-treated sugar beet seeds are used at 80% of the sugar beet acreage (Dewar and Asher, 1994). The effects of seed treatment with insecticides are amply discussed in international and domestic literature. Altmann (1991), for example, points out the duration of action of imidacloprid (2—3 months) and its efficiency in the control of beet flea beetle, as well as of the species *Atomaria linearis*, *Agriotes lineatus* and *Pegomyia hyoscyami*. Wauters and Dewar (1994) report similar data on the action of imidacloprid, but they also mention that carbofuran provides good protection of young sugar beet crops against beet flea beetle, beet leaf miner and *Lygus* bugs. Kimel (1997) in Hungary and Fedorenko and Demjanuk (2003) in Ukraine recommend seed treatment for control of beet weevil if its numbers in old sugar beet fields do not exceed 1—2 individuals per $m^2$.

Studies conducted in our country (Sekulić et al., 1998—2002; Kereši et al., 2003, 2004) showed that seed treatment with insecticides, in addition to controlling soil pests in row crops (with the pest population density up to 5 individuals per $m^2$) successfully controls gray corn weevil in young corn crops, leafcurl plum aphid (*Brachycaudus helichrysi* Kalt.) and corn weevil in sunflower as well as beet flea beetle in young sugar beet crops, or at least reduces the number of field treatments needed for their control.

In the experiments conducted in the period of 2001—2004, especially in 2003, almost all of the tested seed treatment insecticides and their mixtures ensured a significantly better stand of sugar beet crop than the control variant. The highest effects in the maintenance of crop stand were registered in all years in the location A. Šantić, where the population density of the elaterid larvae was the highest. In the first two years of study, in the location Kljajićevo, considerable reductions of the percentage and intensity of damage of young plants by beet weevil were achieved by the application of thiamethoxam and imidacloprid.

The effect of seed treatment on beet flea beetle was most evident in the location R. Šančevi during 2001 (Sekulić et al., 2002) and 2003. In the spring of 2003, the best protection of young plants from beet flea beetles was achieved with thiamethoxam, applied alone or in mixture with tefluthrin and a mixture of imidacloprid + tefluthrin. These treatments ensured significantly lower percentages of damaged plants and intensities of damage than the control variant, while simultaneously ensuring significantly higher plant weight. Similar results, in the same year and in the same location, were obtained with the application of thiamethoxam and a mixture of carbofuran and bifenthrin to encrusted sugar beet seeds (Kereši et al., 2004).

Taking into consideration our own long-termed experience in that field, results of numerous studies conducted around the world and the fact that in the European Union as well as in Ukraine treated sunflower and sugar beet seeds are used practically at the entire acreages of these crops, the use of seed treatment should be expanded in our country because, evidently, it is fully both economically and ecologically justified.


## AKNOWLEGMENT

These studies were partly funded by Ministry of Science and Environment Protection of Serbia Republic (No. of project TR 6856B).


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## СУЗБИЈАЊЕ ШТЕТОЧИНА ШЕЋЕРНЕ РЕПЕ У ПОЧЕТНОМ ДЕЛУ ВЕГЕТАЦИЈЕ ТРЕТИРАЊЕМ СЕМЕНА ИНСЕКТИЦИДИМА

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Резиме

Током 2001—2004. године на подручју Бачке утврђивана је ефикасност инсектицида за третирање семена шећерне репе у циљу сузбијања штеточина у земљишту (ларве фам. *Elateridae*) и смањења штета од репине пипе (*Bothynoderes punctiventris* G e r m.) и репиног бувача (*Chaetocnema tibialis* I l l.). Тестирано је више инсектицида, претежно системичних (карбофуран, тиаметоксам, фипронил, имидаклоприд и клотианидин) и њихових комбинација са пиретроидима у различитим дозама. Оцена ефикасности изражена је преко оствареног биљног склопа, процента биљака оштећених од пипе и бувача, интензитета оштећености од бувача и масе младих биљака.

Ефекат испитиваних инсектицида је варирао, зависно од густине популације штеточина и временских услова у периоду истраживања. Највеће повећање склопа у односу на контролу регистровано је у 2003. години (25—32% на Р. Шанчевима, 21—77% у Сомбору и 63—116% у А. Шантићу), али је и у осталим годинама било врло добро (нарочито у А. Шантићу). Најбоља заштита младих биљака од репине пипе остварена је 2001. и 2002. године у Кљајићеву.

Ефекат инсектицида на репиног бувача најочигледнији је био у 2001. и 2003. години, у локалитету Р. Шанчеви. Док је у контроли 85—100% биљака било оштећено претежно јако, у третманима са имидаклопридом, тиаметоксамом и њиховим мешавинама са пиретроидима проценат оштећених биљака је био много мањи, интензитет оштећености је углавном био слаб, а маса биљака већа.