Pestic. Phytomed. (Belgrade), 33(3-4), 2018, 221–231
DOI: https://doi.org/10.2298/PIF1804221N

UDC 632.951+665.7:632.7:633.31
Original scientific paper

# The effects of a synthetic insecticide and a mineral oil on alfalfa insect pests

**Ivelina Mitkova Nikolova* and Natalia Anastasova Georgieva**

*Institute of Forage Crops, General Vladimir Vazov str. 89, Pleven, Bulgaria*
**Corresponding author: imnikolova@abv.bg*

*Received: 4 September 2018*
*Accepted: 8 October 2018*

**SUMMARY**

The effects of the synthetic insecticide Eforia 043 ZK (thiamethoxam+lambda-cyhalothrin), applied alone and at 1/5 and 2/5 reduced doses in a mix with the mineral oil Akarzin, on *Tychius flavus* Beck. (Coleoptera: Curculionidae), *Adelphocoris lineolatus* Goeze (Hemiptera: Miridae), *Acyrthosiphon pisum* Harr. (Hemiptera: Aphididae), harmful thrips (Thysanoptera) and cicadas (Hemiptera: suborder Auchenorrhyncha) were studied. The efficacy of Eforia (applied alone and in reduced doses) was significantly higher against *A. pisum*, followed by *A. lineolatus* and harmful thrips, compared to cicadas. The insecticidal action of Akarzin had a better protective effect against *A. pisum*, followed by *A. lineolatus*, in comparison with thrips and cicadas. Combined application of the broad-spectrum insecticide Eforia provided good control against insect pests. The mix of Eforia's reduced 1/5 dose with the mineral oil showed the highest toxicity throughout the reporting period. Eforia applied at the reduced dose of 2/5 with Akarzin followed in efficacy. A synergistic effect was observed in combinations and was defined as sub-additive synergism. Reduced dosage of Eforia and decrease in negative environmental impact of the plant protection products is a friendly approach to integrated pest control. It is important to apply innovative formulations of plant protection products that are safer both for plants and the environment.

**Keywords**: Synthetic insecticides; Mineral oil; Reduced doses; Efficacy; Insect pests; Alfalfa

## INTRODUCTION

The complex of harmful insects infesting seed-grown alfalfa crops often includes species that are present in their highest numbers during the second regrowth. They are an important factor that determines productivity. The main insect pests of alfalfa are: *Lygus* spp., *Adelphocoris lineolatus* Goeze, *Bruchophagus roddi* Gussakovskii, *Tychius flavus* Beck, and various species of aphids, including *Acyrthosiphon pisum* Harr., *Therioaphis maculata* Buckton, and *Aphis craccivora* Koch (Karagić et al., 2010; Lugić et al., 2010). A complex of pests may cause sizable damage and so lead to a considerable reduction in yield and quality of alfalfa seeds (Godfrey et al., 2013).

Chemical control involving a wide range of insecticides has led to indicative negative impacts on the environment and on useful organisms in agroecosystems. The adverse effects of these pesticides on human health and the environment have been well documented and proven (Yeo et al., 2003). Also, consumers are exerting increasing pressure to achieve the lowest possible amount of pesticide residues in food (Vu et al., 2007). Using synthetic insecticides can provide excellent control of pests with minimal side effects. However, their sparing use is encouraged within integrated programs to ensure sustainable yields (Dimitrov, 2008) and to reduce the possibility of resistance developing in insect pest populations.

Various studies have aimed not only to look for options and combinations to increase productivity and crop quality but also to improve pest control by combining the use of insecticides with growth regulators, biostimulators and leaf fertilizers in integrated production (Georgieva & Nikolova, 2010; Nikolova & Georgieva, 2010). Some studies have confirmed a synergistic effect when combining insecticides with mineral oils (Al-Mrabeh et al., 2010) and lower toxicity to beneficial entomofauna compared with other pesticides (McLaren, 2008). Combined treatments not only improve the efficiency of agricultural production but also overcome negative consequences of abiotic and biotic stress (Nikolova & Georgieva, 2015).

Reduced use of plant protection products, and their mixing with various products that stimulate plant growth and development, is another environment-friendly approach to integrated pest control. It aims to reduce negative pesticide impacts on the environment. It provides not only good plant protection and higher productivity but also an opportunity to increase plant resistance to certain pests (Tsibulko et al., 2000; Demkin, 2007). It is also important to apply selective pesticides which cause minimal side effects on the biocenoses, and to optimize their doses (Nikolova, 2010).

The aim of this study was to investigate the biological activity of the synthetic insecticide Eforia, i.e. the effects of its application alone, and its reduced doses in a mix with the mineral oil Akarzin, as a method of integrated pest control in alfalfa seed production.

## MATERIAL AND METHODS

A field experiment was carried out in an alfalfa crop (cultivar 'Dara') under non-irrigated conditions at the Institute of Forage Crops (Pleven) over the period 2014-2015. The effects of the synthetic insecticide Eforia 043 ZK, applied alone, and its reduced doses in a mix with the mineral oil Akarzin, on lucerne seed weevil, *Tychius flavus* Beck. (Coleoptera: Curculionidae), alfalfa plant bug, *Adelphocoris lineolatus* Goeze (Hemiptera, Miridae), pea aphid, *Acyrthosiphon pisum* Harr. (Hemiptera, Aphididae), harmful thrips (Thysanoptera) and cicadas (Hemiptera: suborder Auchenorrhyncha) were studied (test variants are listed in Table 1). Treatments were carried out at the beginning of the flowering stage in the second regrowth (BBCH 59-60) for control of those important insect pests as a method of integrated pest management. A split-plot method was used with three replications and fertilization for soil supply with major nutrients. The efficacy of the insecticides was calculated according to a formula by Henderson & Tilton (1955) by recording insect population: one day before treatment in the control plot, and 1, 3, 7 and 9 days after treatment. The method of sweeping with an entomological net was used.

Data were subjected to one-way ANOVA, and the means were compared by Tukey's test at 5% probability ($p \leq 0.05$). Multiple Regression Analysis of Statgraphics Plus (1995) for Windows Ver. 2.1 was also used.

**Table 1.** Characteristics of products

| Products | Active substance | Dose, ml $da^{-1}$ | Producer |
|---|---|---|---|
| 1. Control | Untreated | - | - |
| 2. Eforia 045 ZK | 30 g $l^{-1}$ thiamethoxam + 15 g $l^{-1}$ lambda-cyhalothrin | 125 | Company Syngenta Crop Protection AG, CH-4002, Switzerland |
| 3. Akarzin | 85% mineral oil - paraffin type + 15% emulsifier | 400 | „Agrifflor" Ltd, Bulgaria |
| 4. Eforia 045 ZK + Akarzin | 30 g $l^{-1}$ thiamethoxam + 15 g $l^{-1}$ lambda-cyhalothrin + 85% mineral oil - paraffin type + 15% emulsifier | 100 + 400 | - |
| 5. Eforia 045 ZK + Akarzin | 30 g $l^{-1}$ thiamethoxam + 15 g $l^{-1}$ lambda-cyhalothrin + 85% mineral oil - paraffin type + 15% emulsifier | 75 + 400 | - |

## RESULT AND DISCUSSION

Control of *Acyrthosiphon pisum* by applying the synthetic insecticide Eforia at the manufacturer's recommended dose, and at 1/5 and 2/5 reduced doses in a mix with Akarzin, was excellent in 2014 (Table 2). Toxic effects ranged from 97.7 to 99.8% with minor differences on the first day after treatment (DAT). Treatment with Akarzin alone also exhibited a high insecticidal efficacy (94.8%), although it was significantly below the effects of the variants with Eforia. Three DAT, the efficacy of the synthetic product in different variants exceeded 90%, and significantly the highest was achieved by the mix of 1/5 reduced dose of Eforia and Akarzin. A similar trend was noted on the seventh day when the toxic effect of Eforia on aphids remained high (83.7 - 89.8%). Efficacy was statistically higher after the use of combinations. Nine DAT, a high efficacy of 72.0-75.9% was again exhibited by the combinations and the differences between them were minimal. On the last date, Eforia treatment alone provided a satisfactory protection, considering a reduction in insecticidal activity. A significant reduction in the efficacy of mineral oil was also confirmed.

In 2015, Eforia treatment resulted in weaker protection of plants against pea aphids. Its toxic effect on the first day was high and ranged from 89.0 to 97.0%. The mix with 1/5 reduced dose of Eforia was found to have a significantly higher efficacy than the use of Eforia alone. The efficacy of the insecticide, regardless of dose, remained high, exceeding 80% on the third reporting day (81.4-86.0%), and the differences were insignificant. On the seventh day, the synthetic insecticide manifested a higher toxic effect compared to its use alone and the differences were statistically significant. A satisfactory protective action of Eforia, regardless of the method of use, was observed nine DAT, when the efficacy exceeded 50.0%. Akarzin used alone, showed a low efficacy (28.0%). It was maintained until the ninth day and the differences from the other variants were significant.

**Table 2.** Average number of larvae of *Acyrthosiphon pisum* Harris / 100 sweeps after treatment with plant protection products and their efficacy (E%)

| Products / doses | **1** DAT | | **3** DAT | | **7** DAT | | **9** DAT | |
|---|---|---|---|---|---|---|---|---|
| | 2014 | | | | | | | |
| | No. | E (%) | No. | E (%) | No. | E (%) | No. | E (%) |
| Eforia 045 ZK - 125 ml | 5.5 | 97.7 b | 18.5 | 92.6 b | 51.0 | 83.7 b | 113.5 | 62.6 b |
| Akarzin 400 ml/da | 12.3 | 94.8 a | 32.4 | 87.1 a | 76.7 | 75.4 a | 153.5 | 49.5 a |
| Eforia+Akarzin-100 ml+400 ml | 0.4 | 99.8 b | 7.6 | 97.0 c | 31.8 | 89.8 c | 73.1 | 75.9 c |
| Eforia+Akarzin-75 ml+400 ml | 4.3 | 98.2 b | 10.2 | 95.9 b | 40.6 | 87.0 c | 85.0 | 72.0 c |
| Untreated control | 234.7 | - | 250.4 | - | 312.1 | - | 303.8 | - |
| LSD $_{0.05\%}$ | 2.663 | | 4.161 | | 3.276 | | 4.083 | |
| Products / doses | 2015 | | | | | | | |
| | No. | E (%) | No. | E (%) | No. | E (%) | No. | E (%) |
| Eforia 045 ZK - 125 ml | 5.5 | 89.0 b | 4.0 | 81.4 b | 29.5 | 50.4 b | 63.0 | 50.4 b |
| Akarzin 400 ml/da | 36.0 | 28.0 a | 16.0 | 25.6 a | 65.0 | 18.8 a | 113.5 | 10.6 a |
| Eforia+Akarzin-100 ml+400 ml | 1.5 | 97.0 c | 3.0 | 86.0 b | 24.0 | 70.0 c | 58.0 | 54.3 b |
| Eforia+Akarzin-75 ml+400 ml | 4.0 | 92.0 bc | 3.5 | 83.7 b | 24.5 | 69.4 c | 61.0 | 52.0 b |
| Untreated control | 50.0 | - | 21.5 | - | 80.0 | - | 127.0 | - |
| LSD $_{0.05\%}$ | 5.194 | | 5.104 | | 4.809 | | 7.504 | |

DAT-day after treatment
Means within columns followed by the same letter are not significantly different (p>0.05)

The synthetic insecticide used alone and in combinations against *Adelphocoris lineolatus* exhibited high efficacy from the first (95.3-96.5%) to the seventh DAT, considering also treatments conducted in 2014 (79.6-84.9%) (Table 3). The products provided good protection against the pest species nine DAT. The combinations showed an extended duration of action and significantly better toxic effect, compared to the other variants, from the third to ninth DAT. There were no significant differences between the combinations. The efficacy of the mineral oil was high one week after treatment, and its insecticidal action decreased significantly nine DAT.

Similar results and high efficacy of Eforia variants were found one and three DAT in 2015. The mix of Akarzin with Eforia at 1/5 reduced dose had the highest toxic effect during the reporting days. The combination had a significantly different effect from the individual use of the insecticide one and three DAT, compared to the other Eforia variants. It provided longer plant protection, including the seventh day in 2015, with significant difference from Eforia applied alone. On the last reporting day, insecticide treatments showed a similar satisfactory effect, exceeding 50%, but the differences were insignificant. The mineral oil, used alone, did not have a satisfactory influence on *A. lineolatus* density during that year. Eforia at 1/5 reduced dose and Akarzin contributed to significantly greater efficacy than the synthetic insecticide alone from the first to the seventh DAT, including the day of treatment.

Eforia, applied against another key insect pest in seed production of alfalfa, *Tychius flavus*, achieved excellent control and the efficacy ranged from 92.9 to 95.0% on the first DAT in 2014 (Table 4). It remained high on the third day, between 83.3-85.4%, and differences were insignificant. On the seventh day, values of less than 71% were noted. A statistically higher efficacy was found after Eforia was used alone and in combination at the dose of 100 ml. Unsatisfactory results were observed in all Eforia variants on the ninth day. The mineral oil had an insecticidal effect against *T. flavus*, but it occurred only on the first DAT.

In 2015, Eforia was less efficient than in the previous year as its efficacy ranged from 58.0 to 66.0% on the first day. It remained satisfactory on the third day. Differences between Eforia used alone, and 1/5 reduced dose of Eforia with Akarzin were significant on both reporting days. Mineral oil exhibited an unsatisfactory effect on weevils. A decrease in efficacy of less than 50% was observed in Eforia variants on the seventh day and below 40.0% on the ninth day, and the differences were not statistically significant.

**Table 3.** Average number of adults (adults and larvae) of *Adelphocoris lineolatus* Goeze / 100 sweeps after treatment with plant protection products and their efficacy (E%)

| Products / doses | **1** DAT | | **3** DAT | | **7** DAT | | **9** DAT | |
|---|---|---|---|---|---|---|---|---|
| | 2014 | | | | | | | |
| | No. | E (%) | No. | E (%) | No. | E (%) | No. | E (%) |
| Eforia 045 ZK - 125 ml | 6.7 | 95.3 b | 15.9 | 90.5 b | 47.3 | 76.9 b | 67.4 | 63.8 b |
| Akarzin 400 ml/da | 25.6 | 82.0 a | 35.5 | 78.8 a | 80.1 | 60.8 a | 113.5 | 39.0 a |
| Eforia+Akarzin-100 ml+400 ml | 5.0 | 96.5 b | 6.8 | 95.9 c | 30.9 | 84.9 c | 52.7 | 71.7 c |
| Eforia+Akarzin-75 ml+400 ml | 6.1 | 95.7 b | 11.3 | 93.2 c | 38.7 | 81.1 c | 56.2 | 69.8 c |
| Untreated control | 142.1 | - | 167.4 | - | 204.5 | - | 186.2 | - |
| LSD $_{0.05\%}$ | 3.480 | | 3.576 | | 3.932 | | 2.158 | |
| Products / doses | 2015 | | | | | | | |
| | No. | E (%) | No. | E (%) | No. | E (%) | No. | E (%) |
| Eforia 045 ZK - 125 ml | 4.2 | 83.4 b | 7.5 | 70.0 b | 19.5 | 61.0 b | 79.0 | 54.3 b |
| Akarzin 400 ml/da | 19.5 | 22.0 a | 21.0 | 16.0 a | 45.5 | 9.0 a | 163.5 | 5.5 a |
| Eforia+Akarzin-100 ml+400 ml | 2.5 | 90.0 c | 4.7 | 81.4 c | 16.5 | 67.0 c | 77.5 | 55.2 b |
| Eforia+Akarzin-75 ml+400 ml | 3.5 | 86.0 bc | 7.0 | 72.0 b | 17.5 | 65.0 bc | 80.0 | 53.8 b |
| Untreated control | 25.0 | - | 25.0 | - | 50.0 | - | 173.0 | - |
| LSD $_{0.05\%}$ | 5.398 | | 7.283 | | 5.636 | | 6.193 | |

DAT-day after treatment
Means within columns followed by the same letter are not significantly different (p>0.05)

The number of cicadas and thrips during the study period was sufficiently high to allow evaluation of the impact of products on those two groups of insects. Auchenorhyncha was represented by 7 species - *Empoasca pteridis* Dhlb.; *Erythroneura ribauti* Oss.; *Peragallia sinuata* M.R.; *Psammotettix striatus* L.; *Hyalesthes obsoletus* Sign.; *Reptalus panzeri* P. Lőw; and *Philaenus spumarius* L. *E. pteridis* had a relatively high representation among them. A significant reduction in the total number of cicadas was observed in the treated field, compared to the untreated control (Table 5).

**Table 4.** Average number of adults of *Tychius flavus* Beck / 100 sweeps after treatment with plant protection products and their efficacy (E %)

| Products / doses | **1** DAT | | **3** DAT | | **7** DAT | | **9** DAT | |
|---|---|---|---|---|---|---|---|---|
| | 2014 | | | | | | | |
| | No. | E (%) | No. | E (%) | No. | E (%) | No. | E (%) |
| Eforia 045 ZK - 125 ml | 2.7 | 92.9 b | 7.4 | 84.1 b | 17.7 | 69.5 c | 42.2 | 44.2 b |
| Akarzin 400 ml/da | 27.1 | 28.3 a | 41.8 | 10.3 a | 54.2 | 6.7 a | 73.8 | 2.4 a |
| Eforia+Akarzin-100 ml+400 ml | 1.9 | 95.0 b | 6.8 | 85.4 b | 17.3 | 70.2 c | 42.6 | 43.7 b |
| Eforia+Akarzin-75 ml+400 ml | 2.3 | 93.9 b | 7.8 | 83.3 b | 22.6 | 61.1 b | 44.0 | 41.8 b |
| Untreated control | 37.8 | - | 46.6 | - | 58.1 | - | 75.6 | - |
| LSD $_{0.05\%}$ | 4.571 | | 4.778 | | 3.753 | | 2.841 | |
| Products / doses | 2015 | | | | | | | |
| | No. | E (%) | No. | E (%) | No. | E (%) | No. | E (%) |
| Eforia 045 ZK - 125 ml | 10.5 | 58.0 b | 17.5 | 50.0 b | 17.5 | 41.7 b | 29.5 | 35.9 b |
| Akarzin 400 ml/da | 19.0 | 24.0 a | 27.0 | 22.9 a | 25.0 | 16.7 a | 40.5 | 12.0 a |
| Eforia+Akarzin-100 ml+400 ml | 8.5 | 66.0 c | 14.0 | 60.0 c | 15.5 | 48.3 b | 29.0 | 37.0 b |
| Eforia+Akarzin-75 ml+400 ml | 9.5 | 62.0 bc | 15.5 | 55.7 bc | 17.3 | 42.3 b | 30.0 | 34.8 b |
| Untreated control | 25.0 | - | 35.0 | - | 30.0 | - | 46.0 | - |
| LSD $_{0.05\%}$ | 6.208 | | 7.926 | | 8.412 | | 6.374 | |

DAT-day after treatment
Means within columns followed by the same letter are not significantly different (p>0.05)

**Table 5.** Average number of cicadas (adults and nymphs) / 100 sweeps after treatment with plant protection products and their efficacy (E %)

| Products / doses | **1** DAT | | **3** DAT | | **7** DAT | | **9** DAT | |
|---|---|---|---|---|---|---|---|---|
| | 2014 | | | | | | | |
| | No. | E (%) | No. | E (%) | No. | E (%) | No. | E (%) |
| Eforia 045 ZK - 125 ml | 7.7 | 87.0 b | 21.6 | 68.4 b | 32 | 37.9 b | 31.6 | 29.0 b |
| Akarzin 400 ml/da | 32.7 | 44.9 a | 51.7 | 24.4 a | 42.3 | 17.9 a | 40.5 | 9.0 a |
| Eforia+Akarzin-100 ml+400 ml | 6.7 | 88.7 b | 17.8 | 74.0 c | 23.1 | 55.1 c | 23.2 | 47.9 c |
| Eforia+Akarzin-75 ml+400 ml | 7.0 | 88.2 b | 20.3 | 70.3 bc | 31.4 | 39.0 b | 29.6 | 33.5 b |
| Untreated control | 59.3 | - | 68.4 | - | 51.5 | - | 44.5 | - |
| LSD $_{0.05\%}$ | 4.285 | | 4.364 | | 3.082 | | 5.256 | |
| Products / doses | 2015 | | | | | | | |
| | No. | E (%) | No. | E (%) | No. | E (%) | No. | E (%) |
| Eforia 045 ZK - 125 ml | 13.9 | 61.7 b | 15.6 | 49.4 b | 29.0 | 40.2 b | 20.4 | 31.3 b |
| Akarzin 400 ml/da | 27.4 | 24.5 a | 26.7 | 13.3 a | 42.6 | 12.2 a | 28.5 | 4.0 a |
| Eforia+Akarzin-100 ml+400 ml | 8.5 | 76.6 d | 11.8 | 61.7 c | 18.8 | 61.2 c | 15.0 | 49.5 c |
| Eforia+Akarzin-75 ml+400 ml | 11.2 | 69.1 c | 12.5 | 59.4 b | 22.5 | 53.6 c | 18.6 | 37.4 b |
| Untreated control | 36.3 | - | 30.8 | - | 48.5 | - | 29.7 | - |
| LSD $_{0.05\%}$ | 4.004 | | 10.461 | | 7.945 | | 11.717 | |

DAT-day after treatment
Means within columns followed by the same letter are not significantly different (p>0.05)

The broad-spectrum insecticide Eforia used in combination in 2014 provided good control in the first few days, and product toxicity approached or exceeded 80%. The mix of Eforia reduced 1/5 dose with mineral oil showed the highest toxicity throughout the reporting period. Its efficacy decreased seven and nine DAT, but the effect remained satisfactory. Statistical differences of that variant in relation to the insecticide used alone were detected on the third, seventh and ninth DAT. Eforia alone, and Eforia 2/5 reduced dose + Akarzin exhibited a slightly protective effect on the last reporting day (9 DAT). A satisfactory insecticidal effect of the mineral oil was found only one DAT, and then the cicada counts became comparable to the untreated control.

The impact of products was lower in 2015 than in 2014, but they still provided good protection three DAT. A prolonged insecticidal effect, and a significantly higher efficacy than the other variants were found after treatment with Eforia 1/5 reduced dose + Akarzin (there were no statistical differences, compared to Eforia 2/5 reduced dose + Akarzin on the seventh DAT). Akarzin showed unsatisfactory insecticidal action in that year.

Thrips species found in the second regrowth were: *Thrips tabaci* Lindeman, *T. atratus* Haliday, *Frankliniella intonsa* Trybon, *Haplothrips niger* Osborn and *Odontothrips confusus* Priesner. Among those harmful species, *T. tabaci* had the highest density, followed by *F. intonsa*. Excellent control and high efficacy, sustaining over nine DAT, were found for Eforia at its 1/5 reduced dose in the mix with Akarzin (within 74.3 - 94.1%) in 2014 (Table 6). Differences from the other variants in thrips counts were statistically significant over the reporting period, except for the mix with 2/5 reduced dose on the first and third DAT. Akarzin and Eforia applied at 2/5 reduced dose exhibited a significantly higher efficacy to the insecticide treatment alone in the first three days but on the seventh and ninth DAT the differences were insignificant. Mineral oil had a good toxic effect on the first day after use, satisfactory on the third, but it lost its impact on thrips seven days after that.

Despite the lower density of pest species in 2015, the products exhibited similar effects as in 2014. The efficacy of Eforia variants was high three DAT, followed by a gradual reduction until the ninth day.

The main other pests of alfalfa seed crops, beside those listed, were *Heliothis maritima* Butler (Lepidoptera: Noctuidae), *Bruchophagus roddi* Guss (Hymenoptera: Chalcididae), *Contarinia medicaginis* Kieff (Diptera: Itonididae), *Gonioctena fornicata* Brügg (Coleoptera: Chrysomelidae), and *Subcoccinella*

**Table 6.** Average number of thrips (adults and larvae) / 100 sweeps after treatment with plant protection products and their efficacy (E %)

| Products / doses | **1** DAT | | **3** DAT | | **7** DAT | | **9** DAT | |
|---|---|---|---|---|---|---|---|---|
| | 2014 | | | | | | | |
| | No. | E (%) | No. | E (%) | No. | E (%) | No. | E (%) |
| Eforia 045 ZK - 125 ml | 6.2 | 83.3 b* | 13.8 | 77.0 b | 24.2 | 68.3 b | 26.3 | 64.5 b |
| Akarzin 400 ml/da | 15.6 | 58.1 a | 34.8 | 42.1 a | 46.3 | 39.4 a | 65.7 | 11.2 a |
| Eforia+Akarzin-100 ml+400 ml | 2.2 | 94.1 c | 8.1 | 86.5 c | 16.1 | 78.9 c | 19.0 | 74.3 c |
| Eforia+Akarzin-75 ml+400 ml | 3.1 | 91.7 c | 9.9 | 83.5 c | 23.5 | 69.2 b | 24.8 | 66.5 b |
| Untreated control | 37.2 | - | 60.1 | - | 76.4 | - | 74.0 | - |
| LSD $_{0.05\%}$ | 3.905 | | 3.312 | | 7.816 | | 6.324 | |
| Products / doses | 2015 | | | | | | | |
| | No. | E (%) | No. | E (%) | No. | E (%) | No. | E (%) |
| Eforia 045 ZK - 125 ml | 2.1 | 90.2 b | 5.4 | 80.4 b | 9.7 | 60.4 b | 17.4 | 55.0 b |
| Akarzin 400 ml/da | 12.7 | 40.9 a | 19.1 | 30.8 a | 20.0 | 18.4 a | 35.1 | 9.3 a |
| Eforia+Akarzin-100 ml+400 ml | 1.4 | 93.5 b | 3.2 | 88.4 c | 7.9 | 67.8 c | 12.6 | 67.4 c |
| Eforia+Akarzin-75 ml+400 ml | 1.8 | 91.6 b | 4.5 | 83.7 c | 10.8 | 55.9 b | 15.3 | 60.5 b |
| Untreated control | 21.5 | - | 27.6 | - | 24.5 | - | 38.7 | - |
| LSD $_{0.05\%}$ | 3.427 | | 4.907 | | 6.625 | | 6.536 | |

DAT-day after treatment
Means within columns followed by the same letter are not significantly different (p>0.05)

*vigintiquatuorpunctata* L (Coleoptera: Coccinellidae). They can cause serious damage and a considerable reduction in yield and/or the quality of alfalfa seed. In the present study, the population density of those pests was low over the period of second regrowth. It made difficult the discovery of significant differences in their numbers after treatment, and resultingly the possibility of establishing the impact of synthetic products against those insect pests.

The products under investigation exhibited the most toxic and long-lasting effects against insect pests in the following descending order: *A. pisum*, *A. lineolatus*, phytophagous thrips, *T. flavus* and cicadas (Table 7).

The efficacy of Eforia (applied alone and in combination) was statistically higher against *A. pisum*, *A. lineolatus* and harmful thrips, than to cicadas, while the insecticidal action of mineral oil had a good protective effect against *A. pisum*, followed by *A. lineolatus,* thrips and cicadas.

The pronounced susceptibility of sucking insect pests to Eforia was probably due to their soft body wrap that facilitates insecticide penetration. As the mix of the active substances of contact and systemic insecticides made a strong synergy between them (according to manufacturer's data), Eforia provided a rapid initial effect (knockdown) and high biological efficacy. Using Eforia at the recommended dose provided high or excellent pest control until the seventh DAT, while the product effect on *A. pisum* and *A. lineolatus* was more durable. Akarzin exhibited a high insecticidal effect one week after treatment against *A. pisum* and *A. lineolatus*, while the control level of harmful thrips was satisfactory over a shorter period. The oil is an emulsive concentrate and its active substance contains 85% mineral oil - paraffin type, which acts asphyxiating on insects.

Mineral oils have been used for a long time for control and management of insect pests, both as adjuvants (allowing an increase in toxicity of pesticides) and as insecticides. They cause insect death by inhibiting their respiratory activity or by insecticidal effects, depending on their physical properties (Gardner-Gee et al., 2013). In Bulgaria, Yankova et al. (2009) revealed a high efficacy of Akarzin in control of green peach aphid, *Myzus persicae* Sulz., in pepper. Atanasov et al. (2012) reported a combined use of Akarzin with a fungicide for rust control of *Tranzschelia pruni-spinosae* (Pers) Diet. in a late ripening plum variety. Beside the positive activity of mineral oils, some studies have established a synergistic effect when combining mineral oils with insecticides (Al-Mrabeh et al., 2010), and protection of plants from different viruses by suppression of their transmission (Suranyi, 1999; Margaritopoulos et al., 2009), as well as lower toxicity of the oils to beneficial entomofauna, compared to other pesticides (McLaren, 2008).

Using mineral oils for pest control, according to some authors (Stansly et al., 2002), may cause delays in vegetative plant stages, manifestations of phytotoxicity and yield loss. Various factors determine phytotoxic effects: dose, oil formulation (physical and chemical properties), crop type and environmental conditions, and above all air temperature (Davidson et al., 1991; Angello, 2002). Most formulations of different oils have been improved over the past decade to achieve more efficient and less harmful products (Al-Mrabeh et al., 2010).

Phytotoxicity was reported in the 1990s when formulations were different. Besides, mineral oils were less harmful to the environment, and caused less adverse effects in pest biological control compared to chemical pesticides (Rae et al., 2006). In this study, there was no delay in phenological stages or any phytotoxic events after Akarzin was used. It complemented the positive insecticide characteristics as a plant protection product and allowed its application in integrated pest control.

**Table 7.** Efficacy of products (E %) against alfalfa pest species

| Pest species | E (%) | | | |
|---|---|---|---|---|
| | Eforia | Akarzin | Eforia 1/5 +Akarzin | Eforia 2/5 +Akarzin |
| Acyrthosiphon pisum | 76.0 b | 48.7 c | 83.7 b | 81.3 c |
| Adelphocoris lineolatus | 74.4 b | 39.1 bc | 80.3 b | 77.1 bc |
| Phytophagous thrips | 72.4 b | 31.3 ab | 81.4 b | 75.3 b |
| Tychius flavus | 59.5 a | 15.4 a | 63.2 a | 59.4 ab |
| Cicadas | 50.6 a | 18.8 a | 64.3 a | 56.3 a |
| $LSD_{0.05\%}$ | 18.264 | 13.142 | 15.762 | 19.003 |

Means within columns followed by the same letter are not significantly different (p>0.05)

The high-tech formulation of Eforia, on the one hand, allowed the mixing of the insecticide with various plant protection products, including Akarzin. When combined with insecticides, mineral oils improve the effect of a preparation by reducing surface tension of the working solution, and so creates a uniform film on leaves of treated plants and insect body (according to Bayer Crop Science).

In the present experiment, treatment with 1/5 and 2/5 reduced doses of Eforia and Akarzin increased efficacy and extended the period of plant protection. That was most evident in leaf aphids, as well as plant bugs.

The observed synergistic effects of the combinations were defined as subadditive synergism as it did not exceed the cumulative toxic effects of Akarzin and Eforia individually. Adding Akarzin probably enhanced the penetration of Eforia into leaf tissue, and enabled a more rapid translaminar activity. It resulted in an increase in insecticide efficacy when the active substance was reduced to 1/5 and 2/5 of the recommended dose. The results are consistent with data from other studies (Carvalho Guedes et al., 1995; Pluschkell et al., 1999), according to which the use of mineral oils with insecticides improved their

**Table 8.** Meteorological characteristics

| Month / ten-day periods | | Temperature, ° C | | Rainfall, mm | | Relative humidity,% | |
|---|---|---|---|---|---|---|---|
| | | 2014 | 2015 | 2014 | 2015 | 2014 | 2015 |
| June | 1-10 | 19.4 | 20.8 | 19.6 | 17.0 | 70 | 61 |
| | 11-20 | 20.8 | 22.4 | 15.5 | 39.6 | 72 | 65 |
| | 21-31 | 21.7 | 19.0 | 19.2 | 39.1 | 60 | 60 |
| | Average | 20.6 | 20.7 | 18.1 | 31.9 | 67.3 | 62.0 |
| July | 1-10 | 23.4 | 24.1 | 3.4 | 8.5 | 61 | 62 |
| | 11-20 | 22.2 | 25.6 | 28.5 | 4.1 | 68 | 51 |
| | 21-31 | 23.6 | 27.6 | 39.9 | 8.9 | 71 | 50 |
| | Average | 23.1 | 25.8 | 23.9 | 7.2 | 66.7 | 54.3 |

**Table 9.** Analysis of variance of insecticide efficacy

| Source of variation | Degrees of freedom (df) | Sum of squares (SS) | Influence of factor, % | | Mean square (MS) |
|---|---|---|---|---|---|
| Total | 237 | 346361.1 | 100.0 | | 1461.4 |
| Variants | 159 | 338922.9 | 97.9 | | 2131.6 |
| Factor A - Year | 1 | 28979.0 | 8.4 | * | 28979.0 |
| Factor B - Insect species | 4 | 47282.4 | 13.7 | * | 11820.6 |
| Factor C - Product | 3 | 141089.0 | 40.7 | * | 47029.7 |
| Factor D - Days after treatment | 3 | 76118.9 | 22.0 | * | 25373.0 |
| A x B | 4 | 9077.7 | 2.6 | | 2269.4 |
| A x C | 3 | 2967.5 | 0.9 | | 989.2 |
| A x D | 3 | 1379.5 | 0.4 | | 459.8 |
| B x C | 12 | 3313.5 | 1.0 | | 276.1 |
| B x D | 12 | 1434.3 | 0.4 | | 119.5 |
| C x D | 9 | 666.6 | 0.2 | | 74.1 |
| A x B x C | 12 | 14505.3 | 4.2 | * | 1208.8 |
| A x B x D | 12 | 5109.5 | 1.5 | | 425.8 |
| A x C x D | 9 | 384.1 | 0.1 | | 42.7 |
| B x C x D | 36 | 4101.5 | 1.2 | | 113.9 |
| A x B x C x D | 36 | 2514.2 | 0.7 | | 69.8 |
| Pooled error | 78 | 7438.3 | 2.1 | | 95.4 |

penetration into plant tissue and contributed to better insect pest control. Mujica et al. (2000) found that addition of plant oils to the active substance abamectin increased its efficacy to the extent that the active ingredient may be reduced between a half and three-quarters of its normal dose against the leafminer fly, *Liriomyza huidobrensis* Blanchard. Similar findings have been reported for other pests, such as *Tetranychus urticae* (Schuster & Everett, 1983) and *Plutella xylostella* (Abro et al., 1988). In our country, Yankova et al. (2009) reported an increased efficacy of insecticides at reduced doses in combination with Akarzin.

Another factor affecting the insecticidal activity of test products, besides application type (either alone or in combination), was the weather in experimental seasons (Table 8). The tested plant protection products had a weaker protective effect in 2015 because of a lower average daily air temperatures in combination with a considerable amount of rainfall. Especially indicative were the periods 11-20 June 2014 and 21-31 June 2015, when treatments were performed, and the amount of rainfall in 2015 was 44.0 mm more than in 2014 over the period. Also, despite an oily film that formed on leaves of the treated plants, the retention period was different in the two seasons. In 2015, the oily film on leaves after treatment with Akarzin (alone and in combination) lasted for 15 days. Compared with the previous year of 2014 (18 days), the retention period was shorter due to more rainfall, which had a negative impact on the efficacy of products and their after-effects. Supporting the results were trends revealed by some authors which showed that, under field conditions, oils remained on leaf surface for 10-14 days after application (Simons et al., 1977). Also, small amounts of rainfall (<25 mm per day) did not remove the oily film from treated leaves (Simons & Zitter, 1980).

The results of the analysis of variance (Table 9) showed that all four factors: year, insect species, products and their effects (DAT) had different degrees of impact. Factor C (product type) had a dominant influence and a significant impact on efficacy - 40.7%. The effects of factor D and factor B were weaker (22.0 and 13.7%, respectively) but statistically significant. Meteorological conditions over the years had also lower values but the effect on efficacy variation was significant - 8.4%. Regarding the possible 11 interactions among factors A, B, C and D, only the combination of year, insect species and product (A x B x C) had a statistically significant impact of 4.2%.

From the aspect of alleviation of negative environmental impacts of plant protection products, the use of the synthetic insecticide Eforia at reduced optimum doses in combination with the mineral oil Akarzin is an environment friendly approach to integrated pest control. It is also important to apply innovative formulations of plant protection products that are safer both for plants and for the environment.

## CONCLUSIONS

The efficacy of Eforia (applied alone and at 1/5 and 2/5 reduced doses in a mix with Akarzin) was statistically higher against *A. pisum*, as well as *A. lineolatus* and harmful thrips than to cicadas.

The insecticidal action of the mineral oil Akarzin had a better protective effect against *A. pisum*, followed by *A. lineolatus,* in comparison with thrips and cicadas. Combined use of the broad-spectrum insecticide Eforia provided good control of the test insect pests. The mix of 1/5 reduced dose of Eforia with mineral oil achieved the highest toxicity throughout the reporting period. Eforia used at the reduced dose of 2/5 with Akarzin followed it. A synergistic effect was observed in combinations and was defined as sub-additive synergism.

To reduce the negative environmental impact of plant protection products, the synthetic insecticide Eforia may be used at doses below label rate and in combinations with the mineral oil Akarzin as an ecological approach to integrated pest control.

## REFERENCES

Abro, G.H., Dybas, R.A., Green, A.St.J., & Wright, D.J. (1988). Toxicity of avermectin B1 against a susceptible laboratory strain and an insecticide resistant strain of *Plutella xylostella* (Lepidoptera: Plutellidae). *Journal of Economic Entomology*, *81*, 1575-1580. doi: https://doi.org/10.1093/jee/81.6.1575

Al-Mrabeh, A., Anderson, E., Torrance, L., Evans, A., & Fenton, B. (2010). A literature review of insecticide and mineral oil use in preventing the spread of non-persistent viruses in potato crops. Retrieved from *Potato Council, Agriculture & Horticulture Development Board* at: https://potatoes.ahdb.org.uk/sites/default/files/publication_upload/Review%20of%20Spray%20Oils%20Insecticides%20and%20Potyvirus%20Transmission.pdf

Angello, A.M. (2002). *Petroleum-derived spray oils: chemistry, history, refining and formulation*. In: *Spray oils beyond 2000 – Sustainable pest and disease management* (Beattie A., Watson D., Stevens M., Rae D., Spooner-Hart R., Eds) (pp 2-18). Hawkesbury, Australia; University of Western Sydney. Available at: https://www.researchgate.net/publication/228697386_Petroleum_derived_spray_oils_chemistry_history_refining_and_formulation

Atanasov, A., Dinkova, H., Dragoiski, K., Maneva, S., Georgiev, D., Velichkov, A., & Kirilova, G. (2012). New plant-protection system for organic production in later ripening plum variety. *Acta Entomologica Bulgarica*, 15 (1-2), 44-54. Available at: https: https://www.researchgate.net/profile/Vasilina_Maneva/publication/280012228_Maneva_V_Leceva_I_2012_Listni_vski_HEMIPTERA_APHIDIDAE_pri_nakoj_zrneno_-_zitni_kulturi_v_rajona_na_Ugoiztocna_Blgaria/links/55a3abb608aed99da24c5b1e/Maneva-V-Leceva-I-2012-Listni-vski-HEMIPTERA-APHIDIDAE-pri-nakoj-zrneno-zitni-kulturi-v-rajona-na-Ugoiztocna-Blgaria.pdf (in Bulgarian)

Carvalho Guedes, R.N., Picanco, M.C., Pinheiro Guedes, NM., & Medeira, N.R. (1995). Sinergismo do oleo mineral sobre a toxicidade de inseticidas para Scrobipalpuloides absoluta (Lepidoptera: Gelechiidae) [Synergism of mineral oil with insecticide toxicity for Scrobipalpuloides absoluta (Lepidoptera: Gelechiidae)]. *Pesquisa Agropecuaria Brasileira*, *30*, 313-318. Available at: ttps://www.researchgate.net/publication/281006421

Davidson N.A., Dibble, J.E., Flint, M.L., Marer, P.J., & Guye, A. (1991). *Managing insects and mites with spray oils*. Oakland, CA: University of California. (Special Publication 3347). Available at: https://www.bookdepository.com/Managing-Insects-Mites-with-Spray-Oils-Nita-Davidson/9781879906075

Demkin, A.V. (2007). *Pea aphids and its harmfulness depending on the conditions of mineral nutrition and the use of insecticides*. In *Proceedings of the International Conference „Integrated crop protection and pest monitoring in modern agriculture"* (pp 99-102). Stavropol, Russia: Agrus [in Russian].

Dimitrov, D. (2008). *Harmful and useful entomofauna in some cereal-legumes*. (PhD thesis). General Toshevo, Bulgaria: Agricultural Academy. (in Bulgarian). Available at: http://www.geocities.ws/dimitrov_dai/diss.pdf

Gardner-Gee R, Puketapu, A, MacDonald, F., & Connolly, P. (2013). *Effect of selected oils and insecticides on beneficial insect species*. A report prepared for: Potatoes New Zealand Auckland, New Zealand: New Zealand Institute for Plant & Food Research. Available at: file:///C:/Users/Iv/Downloads/8405-Gardner-Gee-Effect-of-oils-and-insecticides-on-benef-PFR-2013-528....pdf

Georgieva, N., & Nikolova, I. (2010). Study of the influence of new biologically active substances on the grain yield and density of *Acyrthosiphon pisi* Kalt. (Homoptera, Aphididae) in spring forage pea. *General and applied plant physiology*, *36*(1-2), 38-46. Available at: http://www.bio21.bas.bg/ipp/

Godfrey, L., Goodell, P., Barlow, V., Natwick, E., & Long, R. (2013). Insect pest management issues in alfalfa – challenges and questions. In *Western Alfalfa* & *Forage Symposium*. Oakland, CA: University of California. Available at: https://alfalfa.ucdavis.edu/+symposium/2013/files/ppt/13WAS-21_Godfrey_AlfalfaPests.pdf

Henderson, C.F., & Tilton, E.W. (1955). Tests with acaricides against the brow wheat mite. *Journal of Economic Entomology*, *48*, 157-161. Available at: http://www.ehabsoft.com/ldpline/onlinecontrol.htm

Karagić, Đ., Jevtić, G., & Terzić, D. (2010). Forage legumes seed production in Serbia. *Biotechnology in Animal Husbandry 26*(sp.i.), 133-148. (*XII International Symposium on Forage Crops of Republic of Serbia).* Available at: http://symposium.ikbks.com/book-1.pdf

Lugić, Z., Lazarević, D., Erić, P., Mihajlović, V., & Vučković, S. (2010). The state of forage crops production in Serbia. *Biotechnology in Animal Husbandry 26*(sp.i.), 29-47. (XII International Symposium on Forage Crops of Republic of Serbia). Available at: http://symposium.ikbks.com/book-1.pdf

Margaritopoulos, J.T., Tsamandani, K., Kanavaki, O.M., Katis, N.I., & Tsitsipis, J.A. (2009). Efficacy of pymetrozine against *Myzus persicae* and in reducing potato virus Y transmission on tobacco plants. *Journal of Applied Entomology*, *134*, 323–332. doi:10.1111/j.1439-0418.2009.01468.x

McLaren, D. (2008). *Potato virus Y (PVYO and PVYN:O) impact on potato cultivars and management through oil prays*. Agriculture and Agri-Food Canada. Available at: http://www.agr.gc.ca/eng/?id=1299166065707

Mujica, N., Pravatiner, M., & Cisneros, F. (2000). Effectiveness of abamectin and plant-oil mixtures on eggs and larvae of the leafminer fly, *Liriomyza huidobrensis* Blanchard. *CIP Program Report* 1999 – 2000, 161-166. Available at: https://www.researchgate.net/publication/237675185

Nikolova, I. (2010). Study on the efficacy of Regen 800 WG for the control of *Bruchus pisorum* L. (Coleoptera, Bruchidae). In: *Proceedings of the International conference „Present and Future of Aviation Education in the Balkan-Black Sea Region of Europe*" (pp 240-242), Dolna Mitropoliya, Bulgaria.

Nikolova, I., & Georgieva, N. (2010). Use of preparations with different biological effect in spring vetch and their influence on the productivity and insect pest density. *General and Applied Plant Physiology*, *36* (1-2), 28-37. Available at: http://www.bio21.bas.bg/ipp/gapbfiles/v-36/GAPP_v36_1-2_28-37.pdf

Nikolova, I., & Georgieva, N. (2015). Systems of organic farming in spring vetch I: Biological response of sucking insect pests. *Pesticides and Phytomedicine*, 30 (2), 77–84. doi: 10.2298/PIF1502077N

Pluschkell, U., Horowitz, AR., & Ishaaya, I. (1999). Effect of milbemectin on the sweetpotato whitefly, *Bemisia tabaci*. *Phytoparasitica*, *27* (3), 183-191. doi: https://doi.org/10.1007/BF02981457

Rae, D.J., Beattie, G.A.C., Huang, M.D., Yang, Y.P., & Ouyang, G.C. (2006). *Use of horticultural and agricultural mineral oils in citrus IPDM*. Guangdong Guangzhou, China: Scientific Technology Press.

Schuster, D.J. & Everett, P.H. (1983). Response of *Liriomyza trifolii* (Diptera: Agromyzidae) to insecticides on tomato. *Journal of Economic Entomology*, *76*(5), 1170-1174. Available at: https://doi.org/10.1093/jee/76.5.1170

Simons, J.N., McLean, D.L., & Kinsey, M.G. (1977). Effects of mineral-oil on probing behavior and transmission of stylet-borne viruses by *Myzus persicae*). *Journal of Economic Entomology*, 70, 309-315. doi: https://doi.org/10.1093/jee/70.3.309

Simons, J.N. & Zitter, T.A (1980). Use of oils to control aphid born viruses. *Plant Disease, 64*, 542-546. doi: 10.1094/PD-64-542

Stansly, P.A., Liu, T.X., & Schuster, D.J. (2002). Effects of horticultural mineral oils on a polyphagous whitefly, its plant hosts and its natural enemies. In G.A.C. Beattie (Ed.), *Spray Oils Beyond 2000: Sustainable Pest and Disease Management* (pp 120-133). Sydney, Australia: University of Western Sydney Press.

Statgraphics Plus for Windows. Version 2.1. [Computer software]. (1995). Rockville, MD, USA: SAS.

Suranyi, R. (1999). Crop borders and mineral oils: two tactics for management of PVY in seed potatoes. *Aphid alert, 6*(a). Available at: http//Ipmworld.Umn.Edu/Alert.Html.

Tsibulko, V.S., Buryak, Y., Popov, S., & Chornobab, O.V. (2000). *Pea, winter vetch, lucerne. Novelties in the technology of cultivation for seed*. Kharkov, Ukraine: University Press

Vu, T.K.V., Tran, M.T., & Dang, T.T.S. (2007). A survey of manure management on pig farms in northern Vietnam. *Livestock Science*, *112*, 288-297. Available at: https://doi.org/10.1016/j.livsci.2007.09.008

Yankova, V., Markova, D., Todorova, V., & Velichkov, G. (2009). Biological activity of certain oils in control of green peach aphid (*Myzus persicae* Sulz.) on pepper. (*IV Balkan Symposium on Vegetable and Potatoes, Bulgaria). Acta Horticulturae*, *830*(*2*), 619-626. Available at: https://www.actahort.org/members/showpdf?booknrarnr=830_90

Yeo, H-G., Choi, M., Chun, M-Y., & Sunwoo, Y. (2003). Concentration distribution of polychlorinated biphenyls and organochlorine pesticides and their relationship with temperature in rural air of Korea. *Atmospheric Environment*, *37*(27), 3831-3839. Available at: https://doi.org/10.1016/S1352-2310(03)00456-4

# Uticaj sintetičkog insekticida i mineralnog ulja na štetne insekte u lucerki

**REZIME**

Ispitivan je uticaj sintetičkog insekticida Eforia 043 ZK (tiametoksam+lambda-cihalotrin), primenjen nezavisno i u smanjenim dozama od 1/5 i 2/5 preporučene doze, u kombinaciji sa mineralnim uljem Akarzin, na suzbijanje *Tychius flavus* Beck. (Coleoptera: Curculionidae), *Adelphocoris lineolatus* Goeze (Hemiptera: Miridae), *Acyrthosiphon pisum* Harr. (Hemiptera: Aphididae), štetnih tripsa (Thysanoptera) i zrikavaca (Hemiptera: podred Auchenorrhyncha). Efikasnost preparata Eforia (primenjenog nezavisno i u smanjenim dozama) bila je značajno najviša kod *A. pisum*, zatim *A. lineolatus* i tripsa, u poređenju sa zrikavcima. Insekticidno delovanje Akarzina imalo je bolje zaštitno delovanje kod *A. pisum*, a zatim i *A. lineolatus,* u poređenju sa tripsima i zrikavcima. Kombinovano delovanje insekticida širokog spektra Eforia obezbedilo je dobru efikasnost u suzbijanju štetnih insekata. Najvišu toksičnost tokom ispitivanog perioda postigla je kombinacija Eforia u smanjenoj dozi od 1/5 i mineralno ulje. Eforia u smanjenoj dozi od 2/5 sa Akarzinom postigli su sličnu efikasnost. Sinergistički efekat koji je zabeležen u kombinacijama definisan je kao subaditivni sinergizam. Smanjenje doze insekticida Eforia, praćeno smanjenjem negativnog ekološkog uticaja koje imaju preparati za zaštitu biljaka, predstavlja ekološki pristup u integralnoj zaštiti. Važno je primeniti inovativne formule preparata za zaštitu bilja koje su bezbednije kako za biljke, tako i za životnu sredinu.

**Ključne reči:** Sintetički insekticidi; Mineralna ulja; Redukovane doze; Efikasnost; Štetni insekti; Lucerka