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THE EFFECT OF THE CARBOXYL FATTY ACIDS AS A BIOLOGICAL CONTROL PRODUCT AGAINST *Brassicogethes aeneus* F. ON CANOLA

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Abstract

The pollen beetle Brassicogethes aeneus F. (Coleoptera: Nitidulidae) is a major pest of oilseed rape and shows increasing resistance to commonly used insecticides. The aim of the study was to determine the effective dose of potassium salts of carboxyl fatty acids against the pest and to compare their efficacy with two pyrethroid products commonly used in conventional agriculture. The experiment was conducted on the field in the region of Plovdiv, Bulgaria in 2021. Two applications were made in an interval of 7 days between them. The treatment list contained untreated control, potassium salts of carboxyl fatty acids (in two doses: 2.5 l/ha and 5 l/ha), deltamethrin 0.05 l/ha, and tau-fluvalinate 0.2 l/ha. The results obtained show that the application of potassium salts of carboxyl fatty acids in the dose of 5 l/ha significantly reduces the number of the pollen beetle Brassicogethes aeneus F. and even slightly increases the oilseed rape yield. This substance could be successfully used as a plant protection product against the pollen beetle on oilseed rape as an alternative to the applied pyrethroid products.

***Key words**: Brassicogethes aeneus, canola, carboxyl fatty acids, pest control, pyrethroid.*

INTRODUCTION

The pollen beetle *Brassicogethes aeneus* (Fabricius, 1775) (formerly *Meligethes aeneus*) (Coleoptera: Nitidulidae) is one of the most important insect pests in winter oilseed rape (OSR; *Brassica napus* L.) in Europe (Juhel et al., 2017). To produce a high quality yield the agronomists apply a significant amount of pesticides which results in a resistance of the pests against some of the active substances, for example, pollen beetles in Europe became generally resistant to pyrethroids (Hansen, 2003; Heimbach, 2013).

Pyrethroids are mainly used to control insect pests of agriculture, horticulture, forestry and household (Bhatt et al., 2019). Products with that type of active substances are considered relatively safe but their extensive use makes them harmful for humans and animals (Kuivila et al., 2012; Burns and Pastoor, 2018; Bordoni et al., 2019). Many researchers declare their detrimental effects on non-target species including marine fish and aquatic insects (Burns and Pastoor, 2018; Lu et al., 2019). There are also evidences that deltamethrin induces inflammation, nephro- and hepatotoxicity and influences the activity of antioxidant enzymes in tissues (Chrustek et al., 2018).

Alternative integrated pest management strategies for oilseed rape have been actively sought in the last decade, such as repellents (Mauchline et al., 2017), traps (Cook et al., 2004), or resistant cultivars (Herve et al., 2014).

Fatty acids are carboxylic acids with a long aliphatic (carbon chain) tail. They are characterized by the length of the carbon chain (the number of carbon atoms typically ranges from 4 to 24) and the number and position of double bonds (Sims et al., 2014). Toxicity of fatty acids and their salts (soaps) was initially documented almost hundred years ago using soft-bodied insects, such as aphids (Siegler and Popenoe, 1925; Tattersfield and Gimingham, 1927; Dills and Menusan, 1935; Puritch, 1975; Parry and Rose, 1983). The authors observed that the toxicity of saturated fatty acids increased as the chain length increased, peaking at C10-C12, decreasing at C14-16, and again increasing in both the saturated and unsaturated C18 molecules. Fatty acids and their derivative soaps are mainly toxic to soft-bodied insect species, although there is considerable evidence that their range of activity covers a much broader taxonomic spectrum (Sims et al., 2014). Commercial soaps and detergents are also toxic to other hard-bodied insects, such as beetles (van der Meulen and van Leeuwen 1929), Hemiptera (Fulton, 1930), crickets (Abbasi et al., 1984), and ants (Chen et al., 2010). There is not enough information about the action of the purified saturated carboxylic fatty acids against larger insects. Schull (1936) suggested that the fumigant effects of saturated C1-C5 fatty acids can produce significant biological effects on insect tissues. According to Mullens et al. (2009) mixtures of C8, C9 and C10 were highly repellent to houseflies and horn flies at or below 1 mg/cm^2 formulation. In their opinion, the low toxicity and reasonable activity and persistence of these carboxylic acids make them good candidates for development as protective materials against pest flies in livestock settings. Individual longer-chain-length fatty acids were tested, and C11 repelled houseflies for up to 5-8 days, while C12 lasted 2 days. Haritos & Dojchinov (2003) studied the effect of formic acid vapors on the respiration and suggested that they are exceedingly toxic to the rice weevil, *Sitophilus oryzae* (L.), by inhibition of cytochrome c oxidase. Most of the authors investigated the properties of short and middle-chain fatty acids. The data about the pesticidal action of the long-chain fatty acids especially on large insects are scars. This motivated us to investigate the effects of carboxyl fatty acids on pollen beetle severity.

MATERIALS AND METHODS

Plant material, used substances, and experimental design

The experiment was set up in the field in the region of Plovdiv in the period October 2020 July 2021. The oil seed rape cv. DK Implement CL was planted on 02 October 2020 on a depth of 2 cm and plant density of 50 plants per m^2. The experimental design included 5 variants: 1 - untreated control; 2 - potassium salts of carboxyl fatty acids 2.5 l/ha; 3 - potassium salt of carboxyl fatty acids 5.0 l/ha; 4 - deltamethrine 0.05 l/ha (Product Decis 100 EK), and 5 - tau-fluvalinate 0.2 l/ha (Product Mavrik 2 F). Every variant was set up in four replications with a plot size of 30 m^2 each. The fatty acids are applied as a mixture of potassium salts of middle and long-chain carboxyl fatty acids. The applications with the potassium salts of the carboxyl fatty acids were made twice during the vegetation. The pyrethroid products were applied only once (on the day of the first treatment with potassium salts of carboxyl fatty acids). For the applications a backpack sprayer with compressed air was used. The application volume was 300l/ha, operating pressure - 2.3 bar using flat-fan nozzle type. The first spray was performed on 2 April 2021 - BBCH - 55 (majority). The air temperature during the treatment was 12.5°C, cloud cover - 30% and wind velocity - 0.8 mps. The second treatment was done during the BBCH phase 61 (majority), 7 days after the first one (9 April 2021). The air temperature was 17.4°C, cloud cover - 0%, and wind velocity - 1 mps. During the vegetation one herbicidal application was made on October 26 2020 with Cleranda in a dose 2 l/ha and one fungicidal application with Propulse in dose 1 l/ha on April 9 2021.

Analyses of the pollen beetle (*Brassicogethes aeneus* F.) number

For the analyses of the pest number and severity, fifty brunches from an experimental plot were observed and the data are presented as means. The number of the living pollen beetle was counted 5 times (1 - on the day of the first treatment, in the morning before spray; 2 - two days after the first treatment; 3 - on the day of the second treatment; 4 - four days after the second treatment, and 5 - eight days after the second treatment).

Statistical analysis

The data were presented as mean ± SD of 4 replicates. The experimental results were statistically processed with the SPSS program using a one-way ANOVA dispersion analysis using Duncan's comparative method, with the validity of the differences determined at a 95% significance level. The different letters (a, b, c, d) after the average show statistically significant differences between the analyzed variants.

RESULTS AND DISCUSSIONS

The pollen beetle population was observed several times and the number of the living individuals was recorded. The results about the number of the observed pollen beetles are presented on Figures 1-5. On Figure 1 there is information about the number of the pests on the day of the first treatment with carboxyl fatty acids and insecticidal substance (0 DAT 1). It is seen that there are no significant differences in the number of the pests between the tested variants at that time.

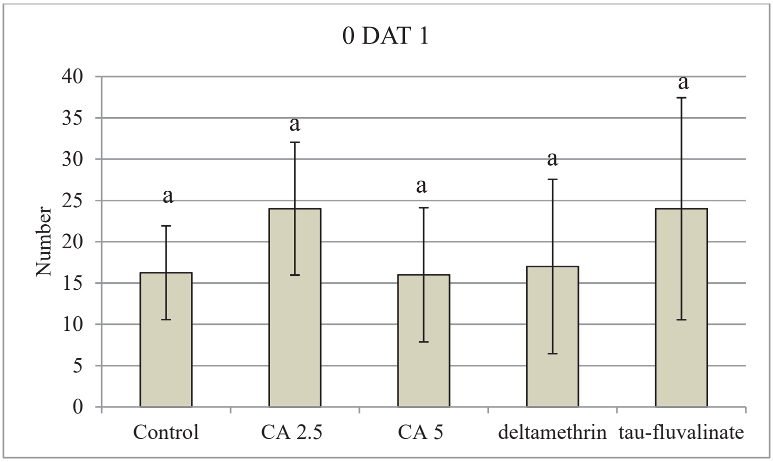

Figure 1. Number of the living pollen beetle on the day of the first treatment (0 DAT 1)

On the other hand, 2 days after the first treatment (2 DAT No 1) there are significant differences between the tested variants. The two products containing potassium salts of carboxyl fatty acids demonstrated a very good pesticide/repelling effect. The CA 2.5 treatment showed a reduction of the beetles by 22.9% compared to the control. As we expected the reduction was even bigger after the application of CA 5 (by 80% compared to the control). The effects of deltamethrin and tau-fluvalinate were similar - a reduction of the adults` number by 81.4 and 82.9% respectively (Figure 2).

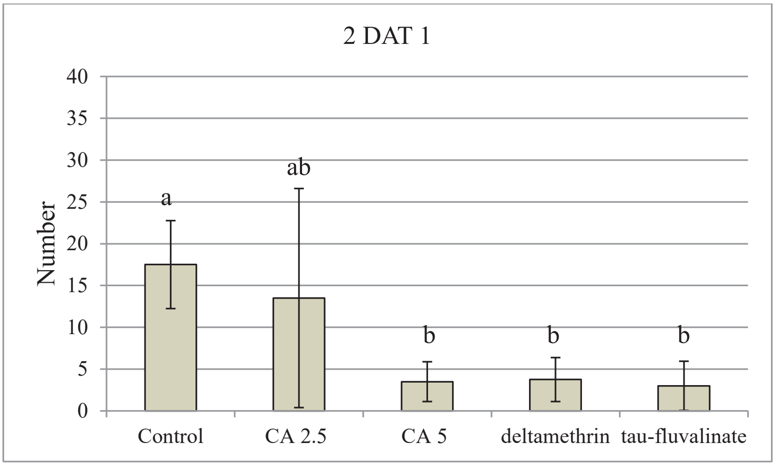

Figure 2. Number of the living pollen beetle 2 days after the first treatment (2 DAT 1)

Seven days after the first treatment a second treatment only with potassium salts of carboxyl fatty acids was performed. On the same day (0 DAT 2) another observation for the number of the pests was made and the differences between the variants were more pronounced. The beetles in variant CA 2.5 were reduced by 59.5% in comparison to the control. On the test plots of the other treatments no living beetles were found (Figure 3).

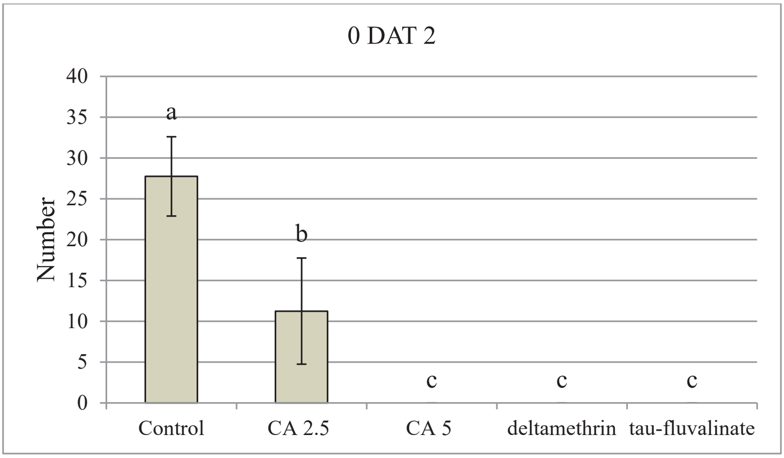

Figure 3. Number of the living pollen beetles at the day of the second treatment (0 DAT 2)

Four days after the second treatment with carboxyl fatty acids the number of the beetles in all the tested variants was very low in comparison to the untreated control. In the CA 2.5 treatment, the reduction was by 87.8% compared to the control. In the other carboxyl acid treatment (dose 5 l/ha), there were no living beetles observed. On the plots treated with deltamethrin there were 97.4% less pests than in the control. On the test plots where tau-fluvalinate was applied, no living beetles were found (Figure 4).

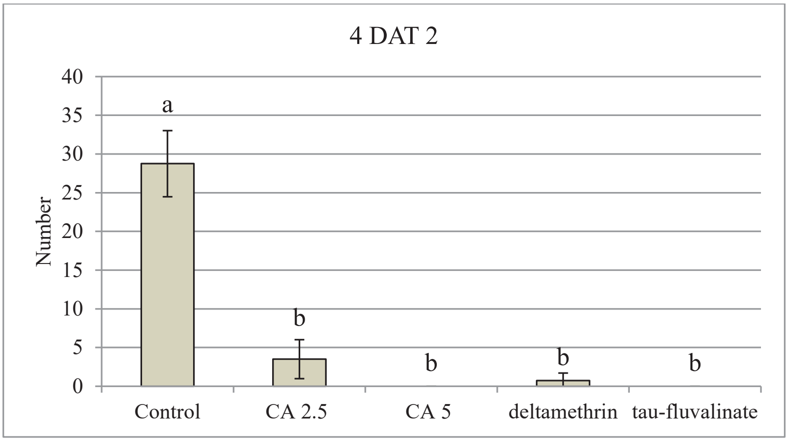

Figure 4. Number of the living pollen beetle 4 days after the second treatment (4 DAT 2)

The data about the number of the pest eight days after the second treatment with carboxyl fatty acids are presented on Figure 5. On the test plots which were treated with carboxyl fatty acids in the dose of 2.5 l/ha the decrease of the number of the living beetles was by 34.1% in comparison to the untreated plots. There where the dose of 5 l/ha was applied, no living beetles were found. The deltamethrin treatment reduced the pest population by 97.7% and the spray with tau-fluvalinate - by 86.2% respectively.

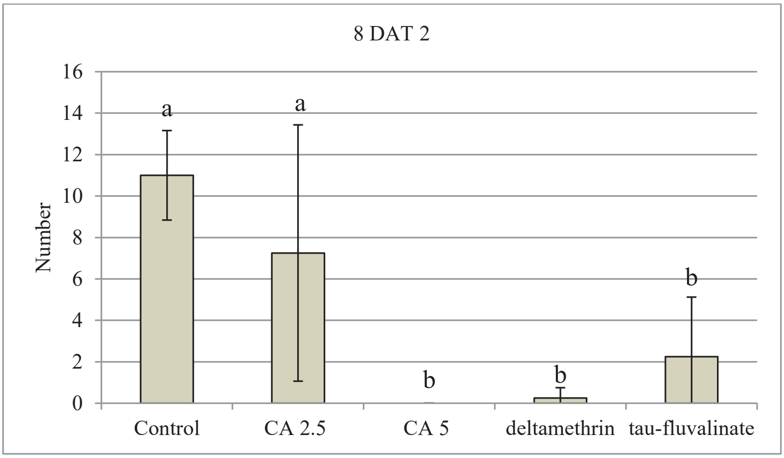

Figure 5. Number of the living pollen beetle 8 days after the second treatment (8 DAT 2)

The data about the calculated pest severity is presented on Figure 6. It is obvious that the pest severity of the control plots increased 7 days after the first treatment and is relatively high during the next 4 days. After that, the value of that parameter was extremely reduced and 15 days after the first application it was lower than at the first day of observation. On the test plots which were treated with potassium salts of fatty acids in dose of 5 l/ha no beetles were observed from day 7 on till the end of the experiment.

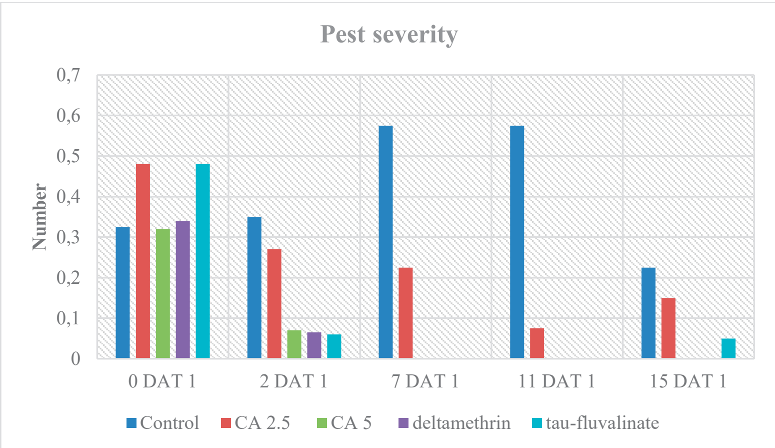

Figure 6. Pest severity (number of living beetles per branch)

The use of carboxylic acid in the dose of 2.5 l, also led to a decrease of the insect number but not to a total lack. The insecticidal treatments extremely reduced the pest population from day 2 on. Till the final count no living beetle was observed on the plot treated with deltametrine but some beetles were found on the plot treated with tau-fluvalinate on day 15. The toxicity effects of fatty acids and their salts (soaps) was documented decades ago using soft-bodied insects, such as aphids (Siegler and Popenoe 1925). Later many other researchers speculated about the connection between the length of the acids and their detrimental or repelling effects

(Sims et al., 2014). They examined the effect of different length chain fatty acids (C14-C20) and reported that the repellent properties of middle length acids (C14) was highly reduced and their toxicity effect was insignificant.
On the other hand, there are several reports about the insecticidal and repellent properties of carboxyl fatty acids with shorter chains. For example, Krzyzowski et al. (2020) used short chain carboxyl fatty acids to investigate their effect on one of the most common pests of stored legumes - the cowpea weevil, *Callosobruchus maculatus*. The authors used undiluted fatty acids including formic, acetic, propionic, butyric, and valeric acid and the results obtained show that these substances demonstrate very highly repellent properties. In our experiment, we used a mixture of middle and long-chain fatty acids in the form of potassium salts and the results show that two applications of these substances could provide very good protection of the treated plots. The application of 5 l potassium salts of fatty acids reduced the pest severity for 15 days. This effect was similar to the effect of one single application of a pyrethroid product.
According to Dheeraj et al. (2013) and Mohamad et al. (2013), potassium salts of fatty acids could be effectively used as synthetic chemicals against snap beans pests and their application led to an increase of the yield quality and quantity. In the current experiment, the yield was also measured and there was a slight increase in all of the tested variant in comparison to the control although it was not statistically significant (Figure 7).
The crop productivity was almost unaffected after the application of 2.5 l/ha potassium salts of carboxyl fatty acids but the rate of 5 l/ha led to an increase by about 4% compared to the untreated control.
The enhancement of the yield was by 6% and by 4% on the plots witch were treated with deltamethrin and tau-fluvalinate respectively (Figure 7.).

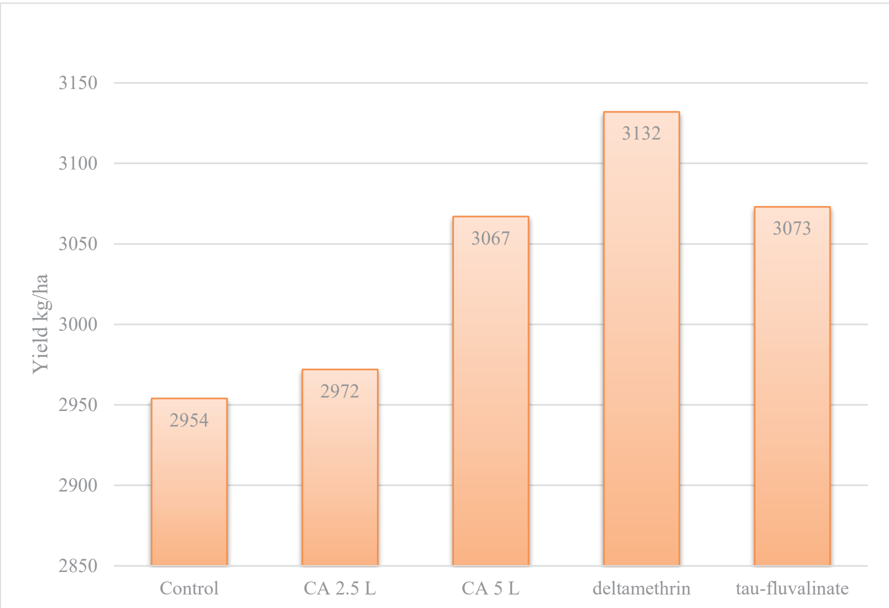

Figure 7. Oilseed rape yield kg/ha

CONCLUSIONS

The current experiment aimed to investigate the effect of the potassium salts of carboxyl fatty acids against the pollen beetle *Brassicogethes aeneus* F. on oilseed rape. The results obtained showed that the application of products containing salts of carboxyl acids resulted in a significant reduction of the pollen beetle adults' number. Both of the tested doses (2.5 l/ha and 5 l/ha) decreased the pest number, but the effect was more pronounced after the application of the higher test dose of 5 l/ha. Fifteen days after the first treatment no living insects were observed on the test plots sprayed with carboxyl acids in the dose of 5 l/ha. The application of the lower dose of 2.5 l/ha could not provide long-lasting protection against the pollen beetle *Brassicogethes aeneus* F. Furthermore the use of the tested substances did not affect the yield quality or quantity negatively but even slightly increased it when 5 l/ha potassium salts of fatty acids were applied. After the analyses performed, we could suggest that the potassium salts of middle and long-chain fatty acids are a potential health-friendly tool for managing the control of *Brassicogethes aeneus* F. In order to minimize the application of pyrethroid insecticides and according to the results obtained, we could recommend the application of potassium salts of middle and long-chain fatty acids in the rate of 5 l/ha as a promising substance for pollen beetle control in oilseed rape.

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