DOI: 10.22620/agrisci.2024.43.026

Effect of different flowering plants on the abundance of pollinators and natural enemies in the oilseed rape agrocenosis

Atanaska Stoeva[1]*, Pavlin Vasilev[1], Adelina Harizanova[1], Mariya Hristozova[2], Atanas Ivanov[1]

[1]Agricultural University – Plovdiv, Bulgaria
[2]Fruit Growing Institute, Plovdiv, Agricultural Academy – Sofia, Bulgaria
***Corresponding author: astoeva@au-plovdiv.bg**

Abstract

The study aims to evaluate different flowering plants in terms of their attractiveness to pollinators and natural enemies, and to provide a list of species optimized for Bulgarian conditions. The field experiments were carried out in 2021-2023 in the region of Plovdiv. A total of 21 flowering plant species were tested. The number of pollinators (honey bees, bumble bees, etc.) attracted was highest on *Phacelia tanacetifolia* (3.3 ± 0.8 SE), *Foeniculum vulgare* (1.4 ± 0.5 SE), *Borago officinalis* (1.3 ± 0.4 SE), and *Coriandrum sativum* (1.2 ±0.3 SE) in 2022. The flowering plant species *P. tanacetifolia, C. sativum*, and *B. officinalis* were among the most attractive to natural enemies, mainly predators. In 2023 *P. tanacetifolia* (25.3 ±1.7 SE), *Echium plantagineum* (15.0 ±2.9 SE), *Fagopirum esculentum* (9.1 ± 1.3 SE), *B. officinalis* (7.4 ±1.9 SE) and *C. sativum* (3.5 ±0.9 SE) attracted the highest number of pollinators, while *Anethum graveolens, Sinapis alba,* and *C. sativum* were the most attractive plants for predators. Therefore, based on the observations in 2021-2023 three plant species lacy phacelia, borage, and coriander are highly recommended for inclusion in flower strip mixtures due to their strong appeal to various beneficial insects.

***Keywords*:** ecosystem service providers, flower stripes, natural enemies, oil seed rape, pests

INTRODUCTION

Winter oilseed rape (*Brassica napus* L., 1753) is the main oilseed crop in Europe, and it is mainly grown for biofuel and edible oil (Pullens et al., 2019). The enormous importance of rapeseed as a source of industrial and edible oil has increased significantly worldwide, while at the same time there has been a multifold increase in pesticide use (Zaller et al., 2008). A study by Dent (2012) shows the results of trials involving the replacement of synthetic pesticides with biological equivalents. These include biopesticides based on bacteria, fungi, viruses, entomopathogenic nematodes, pheromones, and macrobiological agents such as predators and parasitoids. Other alternatives to chemicals include the use of pest-resistant varieties, including transgenic crops, and elements of crop technology such as crop rotation, intercropping, tillage systems, changing sowing dates, seeding rates and overall improved habitat management.

Winter oilseed rape is attacked by six major pests that often require control by growers to protect seed yield: the cabbage stem flea beetle, pollen beetle, cabbage seed weevil, cabbage stem weevil, rape stem weevil and brassica pod midge (Williams, 2010). The problem of the development of resistance of some of the pests to plant protection products (mainly to pyrethroids, currently widely used in winter oilseed rape), requires the development of alternative control strategies. The creation of conditions for the protection and maintenance of populations of beneficial organisms (pollinators, predators and parasitoids) can be used as a key point of a modern integrated pest

management system in the agrocenosis of oilseed rape. Optimizing Agri-Environmental Schemes (AES) is needed, aiming to maximize the use of ecosystem services, such as pollination and biological control. Improving the ecosystem services provided in the target crop (canola) can be optimized by providing habitat, food and alternative hosts for crop pollinators and natural enemies of its pests (Hatt et al., 2018).

A number of authors point to the role of trap plants in reducing damage from enemies (Hokkanen, 1989; Hokkanen & Menzler-Hokkanen 2018). In spring, for example, turnips can be used as a trap plant to protect canola from the pollen beetle.

The use of flower strips can be an important part of the integrated pest management and contribute to lowering pressure on agroecosystems. This is the reason why they are even more often implemented as part of agri-environmental programs. They can prevent the reduction of species diversity and provide ecosystem services, such as pollination and natural pest control (Kowalska et al., 2022). It is well known that flowering plants are attractive to beneficial insects. The attractiveness depends on many factors including morphology and color (Colley & Luna, 2000). Many beneficial insects like hoverflies, lacewings and some ladybirds need amino acids and carbohydrates as an energy source and for egg production and flowering plants could provide these compounds (Altieri & Whitcomb, 1979). Pollen and nectar also supply adult parasitic wasps with energy (HDRA, 1993).

The aim of the present study is to evaluate the ability of different types of flowering plants suitable for seeding flower strips in the agrocenosis of winter oilseed rape, on the one hand, to attract and maintain the populations of important ecosystem service providers (pollinators, predators, parasitoids), and on the other hand, to reduce the risk of crop pests.

MATERIALS AND METHODS

The study was conducted in field conditions in the experimental field of the Agricultural University, Plovdiv in 2021-2023. For this purpose, a crop of winter oilseed rape (EC Capello variety) was created, in which 4 strips of flowering plant species were sown. Each of these strips included 21 species of plants (Table 1), sown in separate squares, each with an area of 1 m^2 (1m x 1m), standing 1 m apart from each other and from the canola. The four flowering strips represented four replicates of the studied plants and were spaced 5 m apart.

Table 1. List of flowering plant species included in the field experiment carried out in the experimental field of the Agricultural University, Plovdiv in 2021-2023

No	Latin name	No	Latin name
1	*Foeniculum vulgare*	12	*Taraxacum officinale*
2	*Coriandrum sativum*	13	*Cuminum cyminum*
3	*Anethum graveolens*	14	*Hyssopus officinalis*
4	*Matricaria chamomilla*	15	*Arnica montana*
5	*Pimpinella anisum*	16	*Nigella damascene*
6	*Fagopyrum esculentum*	17	*Echium plantagneum*
7	*Calendula officinalis*	18	*Centaurea cyanus*
8	*Sinapis alba*	19	*Trifolium pratense*
9	*Phacelia tanacetifolia*	20	*Linum sp.*
10	*Malva sylvestris*	21	*Onobrychis viciifolia*
11	*Borago officinalis*		

The monitoring of the beneficial entomofauna started from the beginning of flowering of the plants sown in the strip squares in the canola crop. It was carried out weekly or once every two weeks and continued until the end of flowering of the respective plant species.

Two methods were used to count the number of pollinators and other insect visitors of flowering plants (predators and parasitoids). The first method was direct visual observation of flowering plants and counting the number of the main groups of pollinators (honeybees, wild bees, bumblebees, syrphid flies, nectar-feeding flies and butterflies), as well as parasitoids and some of the important predators (ladybugs, lacewings, predatory bugs, etc.). In the second method, the insects were collected using a sweep net and stored in ethyl alcohol for further identification.

The obtained results were processed statistically and the data were analyzed by one-way ANOVA with the statistical software package IBM SPSS Statistics 19, using Tukey`s test HDS (Honestly Significant Difference) at significance level a = 0.05.

RESULTS AND DISCUSSION

The study followed a comprehensive approach, including selection of different flowering plant species easy to sow and grow under field conditions, assessment of species composition and population density of attracted beneficial insects and providing a list of plants optimized for local conditions. Some of the preliminary results of this study are included in the PhD dissertation (Ivanov, 2024).

Of the 21 plant species tested in the first year of study, three (*Hyssopus officinalis*, *Arnica montana* and *Echium plantagineum*) did not germinate and were excluded from the experiment. In the second experimental year, four species fell: *Malva sylvestris*, *Taraxacum officinale*, *Cuminum cyminum*, and *Arnica montana*.

The reported beneficial entomofauna found on flowering plants is divided into two groups – pollinators (honeybees, bumblebees and syrphid flies) and other flower-visiting species (mainly predators).

In 2022, phacelia (*Phacelia tanacetifolia*) attracted the largest number of pollinators – an average of 3.45 during the flowering period, followed by fennel (*Foeniculum vulgare*) - 1.65, coriander (*Coriandrum sativum*) and borage (*Borago officinalis*) – 1.5 (Fig. 1). The smallest number of pollinators were attracted to cumin, chamomile, buckwheat and flax – on average less than 0.5. One-way ANOVA of the obtained results and the Tukey HDS (Honestly Significant Difference) test at a significance level of a = 0.05 showed statistically significant differences in the number of pollinators recorded in the different flowering species ($F=4.58$, $p=0.00<0.05$).

The analysis shows that depending on their ability to attract pollinators the studied plant species fall into two different groups (marked in Fig. 1 with a different letter). Phacelia significantly differs from the other flowering plants included in the test.

The group of entomophagous insects (predominantly predatory species) visiting the flowering plants showed the greatest preference for phacelia (*Phacelia tancetifolia*), clover (*Trifolium pratense*) and common sainfoin (*Onobrychus vicifolia*) (Fig. 2). In all three plant species, the average number of predatory insects attracted during the vegetation of 2022 was over 1. The average number of attracted predators was over 0.5 in coriander, cumin, fennel and anise.

The species dandelion (*Taraxacum officinale*), flax (*Linum* sp.) and white mustard (*Sinapis alba*) were the least attractive for predatory insects (Fig. 2).

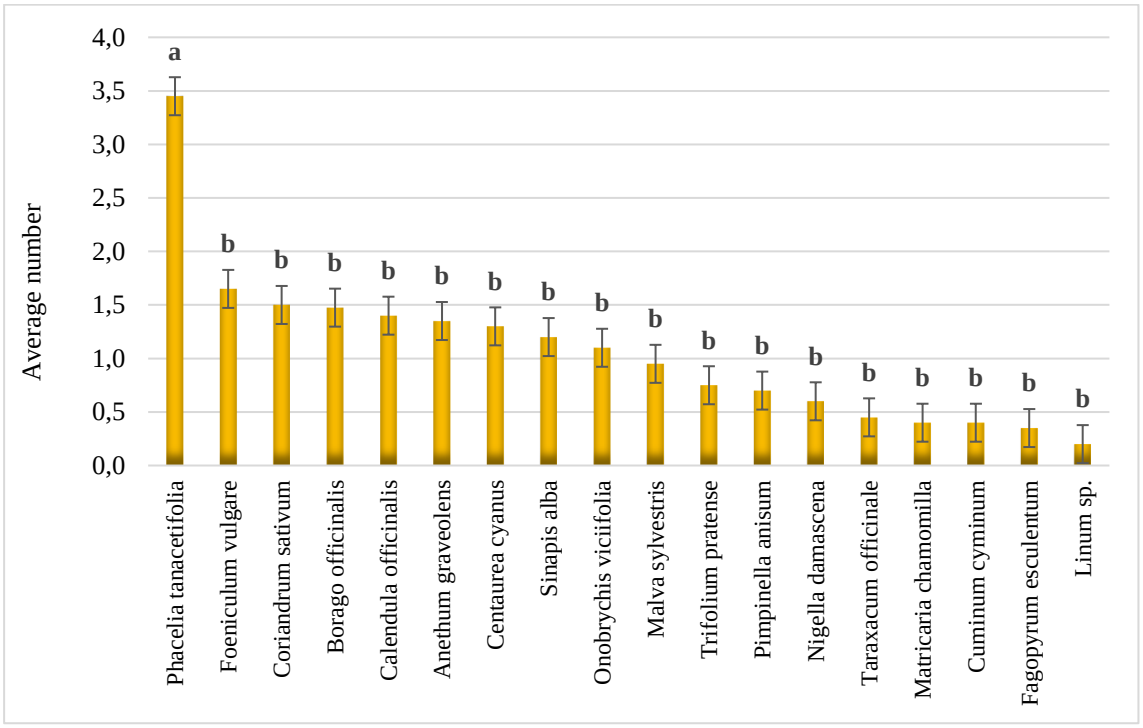

Figure 1. Average population density of pollinators attracted to flowering plants in oilseed rape agrocenosis in 2022 (ANOVA, Tukey's HSD, $p < 0.05$ (Different letters indicate statistically significant differences by Tukey's HSD tests ($p<0.05$))

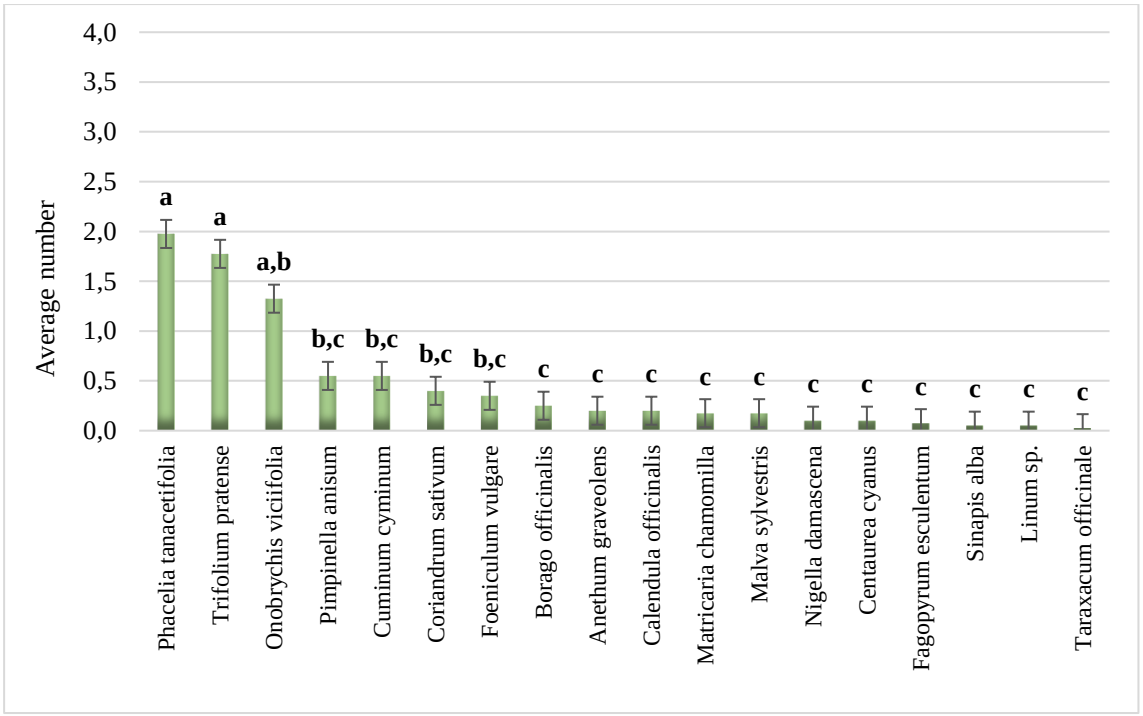

Figure 2. Average population density of predatory insects recorded on the flowering plants in the oilseed rape agrocenosis in 2022

The results of the analysis of variance showed that the established differences between individual flowering species in their ability to attract predators were statistically proven (F=7.608, p=0.00<0.05). Based on their attractiveness for predatory insects, the tested plants fall into 3 groups (Fig. 2), with the phacelia and clover being significantly more attractive than the others.

The results in the second experimental year to a certain extent repeat those obtained in the previous one with this difference that, in general, the number of recorded insects (mainly pollinators) visiting the flowers is higher (Fig. 3). The highest number of pollinators was attracted again by phacelia (average 25.28), followed by *Echium plantagineum*, buckwheat, borage, white mustard and coriander. Phacelia, borage and coriander confirm their role as species with a good ability to attract pollinators.

One-way analysis of variance proved the statistical significance of the differences found (F=20.17, p=0.00<0.05). The Tukey's HSD test divided the flowering plant species into 4 groups regarding their attractiveness to pollinators.

Regarding natural enemies (predators), a certain difference was observed compared to 2022 (Fig. 4). Dill (*Anethum graveolens),* white mustard (*Sinapis alba*) and coriander (*Coriandrum sativum*) attracted the largest number of predatory insects. Borage and phacelia were also included in the group of species preferred by predators. The analysis of the data showed a statistically significant difference in the ability of different flowering plants to attract predators, (F=6.23, p=0.00<0.05), and on this basis the tested plants were divided into 5 groups.

In the experiment of Sievwright et al. (2006) four flowering plants including coriander (*Coriandrum sativum*), corn Marigold (*Glebionis segetum*), fennel (*Foeniculum vulgarum*) and phacelia (*Phacelia tanacetifolia*) were assessed. These plants have been previously reported as effective attractants (Verkerk, 2001; Colley & Luna, 2000; Morris & Li, 2000; Solomon et al., 1999). Flower strips have a positive effect on the development, wintering and multiplication of the natural enemies of the crop pests (Kowalska et al., 2022).

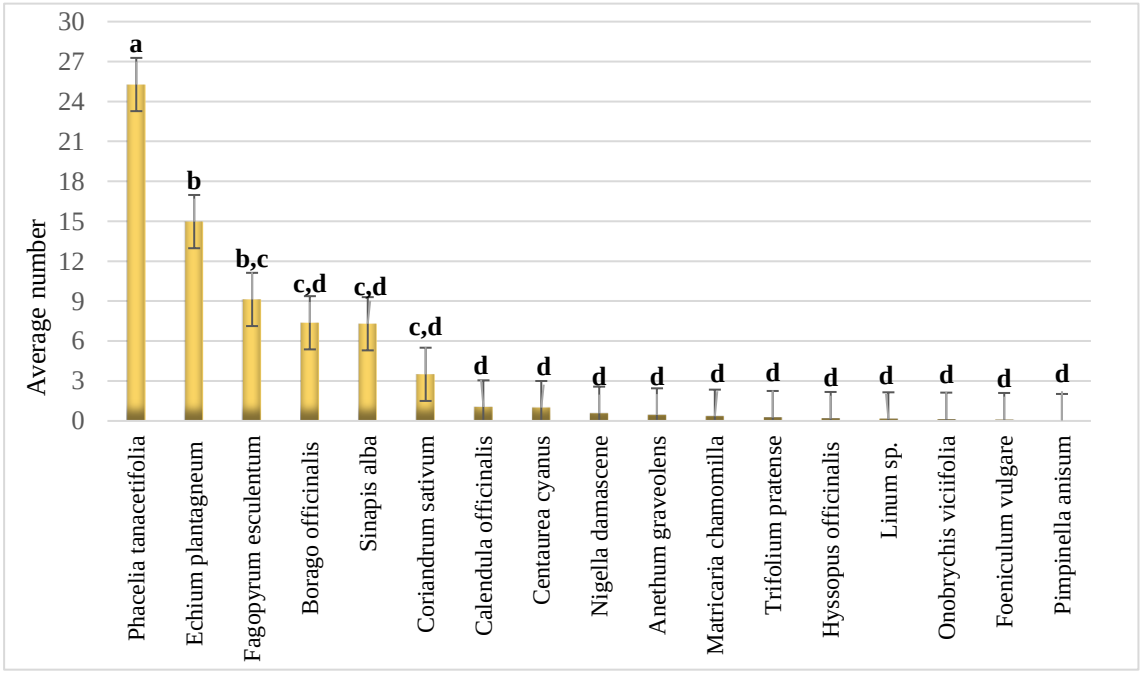

Figure 3. Average population density of pollinators attracted to flowering plants in oilseed rape agrocenosis in 2023

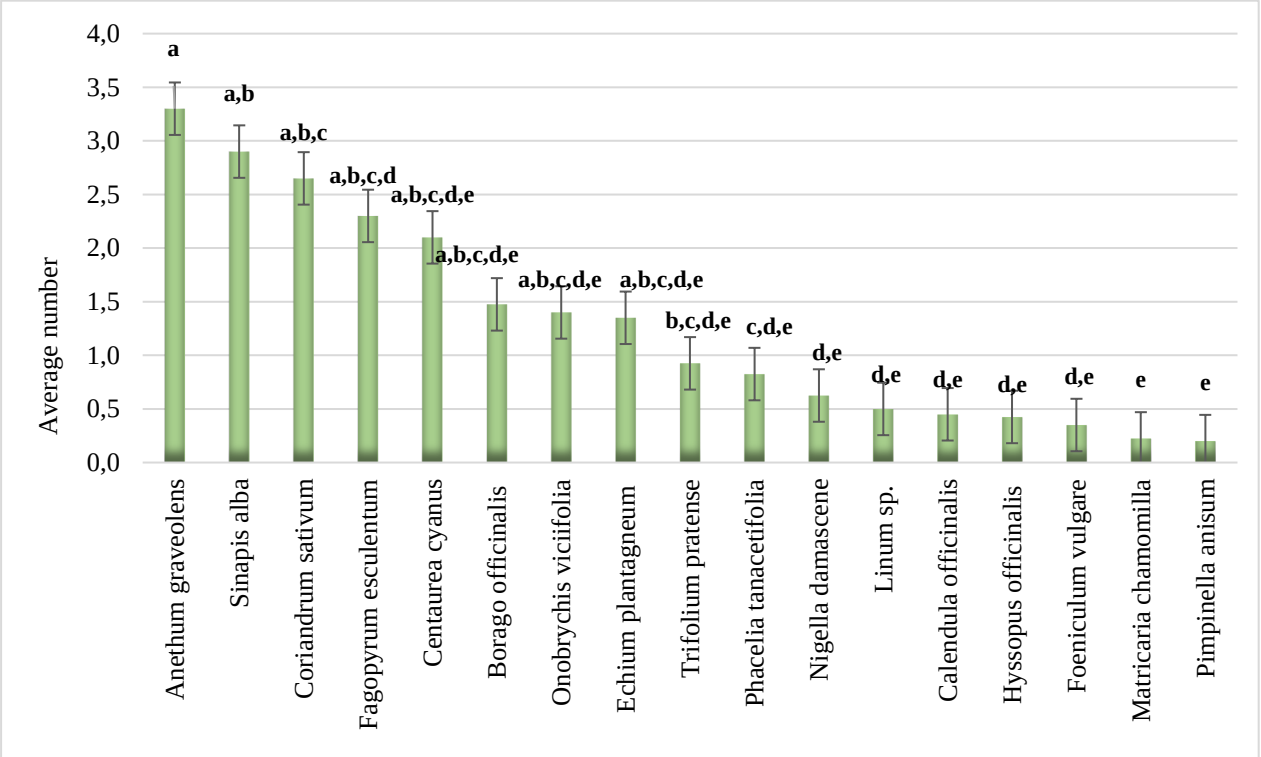

Figure 4. Average population density of predatory insects recorded on the flowering plants in the oilseed rape agrocenosis in 2023

Analysis of the entire complex of flower-visiting insects showed that its diversity is different in different flowering plants. In 2022, several plant species, borage, fennel, phacelia, and common sainfoin, attracted insects from all groups observed, and coriander, fennel, and red clover attracted more than two groups of beneficial insects (Fig. 5).

The analysis of the data from 2023, representing the ability of different flowering plants to attract pollinators from more than one group, showed that four of the studied plant species were attractive to all groups of observed insects - borage, buckwheat, phacelia, and purple viper's-bugloss (Fig. 6).

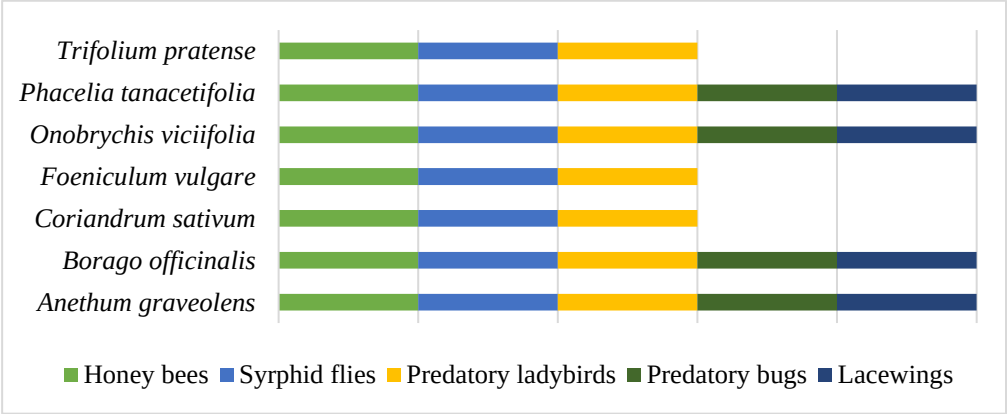

Figure 5. List of flowering plant species preferred by most pollinators and predators recorded in 2022

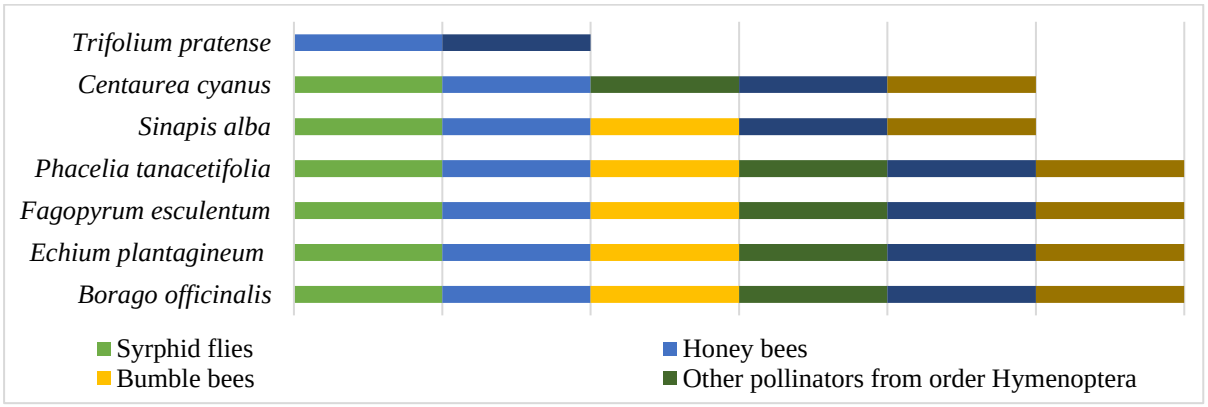

Figure 6. List of flowering plant species preferred by most pollinator groups recorded in 2023

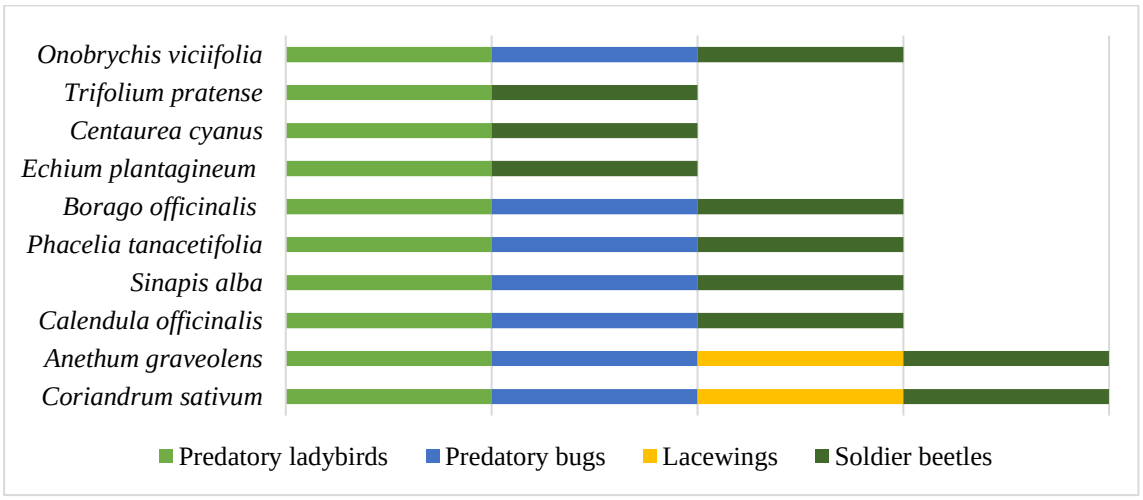

Figure 7. List of flowering plant species preferred by most predators recorded in 2021-2023

Analyzing in a similar way the species having the ability to attract predatory insects from a larger number of families, we could say that 10 of the 17 observed species in 2023 were attractive to more than one group of predators, the object of monitoring - predatory ladybirds, predatory bugs, and lacewings (Fig. 7). Again among them are phacelia, borage and coriander. Coriander and dill are attractive to all groups of reported predators. In the work of Sievwright et al. (2006), phacelia is reported to demonstrate high attractiveness to beneficial insects. According to the authors, the most attractive plant at the end of the season was phacelia and insects preferred the other experimental plants when they were in flower.

According to Baden-Bohm et al., (2022) the species composition of the flower mixture and flower structure affect the honeybees' occurrence. High quality flower strips, which provide much pollen and nectar and are evenly spread, are more attractive to bees, unlike flower strips of poor quality, which are less satisfying for bees.

Summarizing the results obtained from the experiment with flowering plant species conducted in 2021-2023 and the data analysis carried out, we can say that three flowering plant species can be recommended for sowing flower strips in the agrocenosis of winter oilseed rape and these are: phacelia (*Phacelia tanacetifolia*), borage (*Borago officinalis*) and coriander (*Coriandrum sativum*). They stand out as the plants that attract the largest number of pollinators and predators, and from the widest range of taxonomic groups.

CONCLUSIONS

Strips of flowering plant species in canola crops attract beneficial insects and enhance ecosystem services such as pollination and biological control. The largest number of pollinators in both years of the study was found on phacelia (*Phacelia tanacetifolia*). The largest number of predators in 2022 was found on phacelia (*Phacelia tanacetifolia*), and in 2023 - on fennel (*Anethum graveolens*). Phacelia, borage (*Borago officinalis*), coriander (*Coriandrum sativum*), white mustard (*Sinapis alba*), fennel (*Anethum graveolens*), calendula (*Calendula officinalis*) and common sainfoin (*Onobrychis vicifolia*) are the plant species which flowers attract pollinators and predators from the broadest range of families.

Three plant species phacelia (*Phacelia tanacetifolia*), borage (*Borago officinalis*) and coriander (*Coriandrum sativum*) can be recommended for sowing strips of flowering plant species in agrocenosis of winter oilseed rape.

ACKNOWLEDGEMENTS

The study is part of the work on an international project under the Horizon 2020 program: "Stacking of ecosystem services: mechanisms and interactions for optimal crop protection, pollination enhancement, and productivity - EcoStack", 773-554-EcoStack-H2020-SFS-2016- 2017/H2020-SFS-2017-2 (2018 -2023).

REFERENCES

Altieri, M. A., & Whitcomb, W. H. (1979). The potential use of weeds in the manipulation of beneficial insects. *HortScience*, 14(1), 12-18. https://doi.org/10.21273/HORTSCI.14.1.12

Baden-Böhm, F., Thiele, J., & Dauber, J. (2022). Response of honeybee colony size to flower strips in agricultural landscapes depends on areal proportion, spatial distribution and plant composition. *Basic and Applied Ecology*, 60, 123-138. http://dx.doi.org/10.1016/j.baae.2022.02.005

Colley, M. R., & Luna, J. M. (2000). Relative attractiveness of potential beneficial insectary plants to aphidophagous hoverflies (Diptera: Syrphidae). *Environmental Entomology*, 29(5), 1054-1059. http://dx.doi.org/10.1603/0046-225X-29.5.1054

Dent, D. (2012). Overview of agrobiologicals and alternatives to synthetic pesticides. In *The Pesticide Detox* (pp. 70-82). Routledge.

Hatt, S., Uyttenbroeck, R., Lopes, T., Chen, J. L., Piqueray, J., Monty, A., & Francis, F. (2018). Effect of flower traits and hosts on the abundance of parasitoids in perennial multiple species wildflower strips sown within oilseed rape (*Brassica napus*) crops. Arthropod-Plant Interactions, 12(6), 787-797. https://doi.org/10.1007/s11829-017-9567-8

HDRA (1993) *Step by step organic gardening: gardening with beneficial insects for natural pests control*. Henry Doubleday Research Association, Ryton. Coventry

Hokkanen, H. M. T. (1989). Biological and agrotechnical control of the rape blossom beetle *Meligethes aeneus* (Coleoptera, Nitidulidae). 53, 25-29.

Hokkanen, H. M. T., & Menzler-Hokkanen, I. (2018). Trap cropping as a delivery platform for RNAi-based targeted control of the pollen beetle *Brassicogethes aeneus*. In *Mitteilungen der Deutschen Gesellschaft fur Allgemeine und Angewandte Entomologie*, 21, 143-145.

Ivanov, A. I. (2024). Inovativni metodi za kontrol na ikonomicheski vazhni

nepriyateli po zimna maslodayna rapitsa [Innovative methods for controlling economically

Kowalska, J., Antkowiak, M., & Sienkiewicz, P. (2022). Flower strips and their ecological multifunctionality in agricultural fields. *Agriculture*, 12(9), 1470. https://doi.org/10.3390/agriculture12091470

Pullens, J. W. M., Sharif, B., Trnka, M., Balek, J., Semenov, M. A., & Olesen, J. E. (2019). Risk factors for European winter oilseed rape production under climate change. *Agricultural and Forest Meteorology*, 272, 30-39. https://doi.org/10.1016/j.agrformet.2019.03.023

Sievwright, H. C., Sutton, G. L., & Rosenfeld, A. (2006). *Plants for predators-a participatory experiment.* Aspects of Applied Biology 79, What will organic farming deliver? COR 2006, 121-124.

significant pests in winter oilseed rape]. (Doctoral dissertation, Agricultural University – Plovdiv) [In Bulgarian]. BPOS Repository. http://hdl.handle.net/20.500.12641/68116

Verkerk, R. (2001). *Farmers' friends-recognition and conservation of natural enemies of vegetable pests.*

Williams, I. H. (2010). The major insect pests of oilseed rape in Europe and their management: an overview. In: *Williams, I. (eds) Biocontrol-Based Integrated Management of Oilseed Rape Pests*. Springer, Dordrecht. 1-43. https://doi.org/10.1007/978-90-481-3983-5_1

Zaller, J. G., Moser, D., Drapela, T., Schmöger, C., & Frank, T. (2008). Effect of within-field and landscape factors on insect damage in winter oilseed rape. *Agriculture, ecosystems & environment*, 123(1-3), 233-238.

Zhang, X., Axmacher, J. C., Wu, P., Zhang, X., & Liu, Y. (2019). Productive oilseed rape strips supplement seminatural field-margins in promoting ground-dwelling predatory invertebrates in agricultural landscapes. *Journal of Insect Science*, 19(3), 18. https://doi.org/10.1093/jisesa/iez055

Zheng, X., Koopmann, B., Ulber, B., & von Tiedemann, A. (2020). A global survey on diseases and pests in oilseed rape - current challenges and innovative strategies of control. *Frontiers in Agronomy*, 2, 590908. https://doi.org/10.3389/fagro.2020.590908