Currently, the hybrid cultivars are predominant in the cultivation of winter oilseed rape in Europe. The availability of such a large number of hybrid cultivars strongly affects the proportion of the total crop area grown. Estimates suggest European countries plant approximately 90% hybrid cultivars (Kleffmann Group 2018)

There have been suggestions that the cultivation of hybrid cultivars instead of traditional line cultivars could affect the visitation by honey bees and other pollinators. Sláma (2019) stated (oral statement) that winter rape stands are less frequented by bees due to the cultivation of hybrid cultivars. He also reports lower yields of honey from these stands.

However, oilseed rape is still considered by most growers to be a very attractive crop for insect pollinators due to the deep yellow color of its flowers, its special aromas, and its sugar content in nectar (Masierowska and Pietka 2014). Abrol (2011) also noted that oilseed rape provides about 25 to 91 million flowers per hectare per day, making it one of the most important and safest sources of bee pasture. Veselý et al. (2009) found that older line cultivars with a high content of erucic acid and glucosinolate had similar flowering biology to the currently grown hybrids.

Stanley et al. (2013) report that a wide variety of insects, including bees (Apis mellifera L.), bumble bees (Bombus sp.), other bees and flower flies (Eristalis sp.), also visit oilseed rape. However, a more significant effect for both pollinator groups appears to have been the color of the flower.

Keywords: attractiveness; crop pollination; oilseed rape hybrid; agroecology

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**Material and methods**

In 2015–2017, the small-plot experiments were conducted for the purpose of examining the influence of oilseed rape on the visitation of two groups of pollinators: bumble bees (Bombus terrestris L. and Bombus lapidaries L.) and honey bee (Apis mellifera L.).

**Description of location.** The experiments were carried out at a demonstration field belonging to the Czech University of Life Science Prague (50°12′99.7″ N, 14°37′37″ E).

**Experiment with oilseed rape cultivars.** In the first year of the experiment, pollinator visitation was observed on winter oilseed rape cultivars: Artoga, DK Explicit, Sidney, Sherpa, and Witt. During the second year, the experiment was extended to include the cultivars: Andromeda, Arabella, Dozzen, DK Explicit, Sidney, Sherpa, and Witt. During the first year of the experiment, pollinator visitation was observed on winter oilseed rape cultivars: Artoga, DK Explicit, Sidney, Sherpa, and Witt. During the second year, the experiment was extended to include the cultivars: Andromeda, Arabella, Dozzen, DK Explicit, Sidney, Sherpa, and Witt. During the first year of the experiment, pollinator visitation was observed on winter oilseed rape cultivars: Artoga, DK Explicit, Sidney, Sherpa, and Witt. During the second year, the experiment was extended to include the cultivars: Andromeda, Arabella, Dozzen, DK Explicit, Sidney, Sherpa, and Witt. During the first year of the experiment, pollinator visitation was observed on winter oilseed rape cultivars: Artoga, DK Explicit, Sidney, Sherpa, and Witt. During the second year, the experiment was extended to include the cultivars: Andromeda, Arabella, Dozzen, DK Explicit, Sidney, Sherpa, and Witt. During the first year of the experiment, pollinator visitation was observed on winter oilseed rape cultivars: Artoga, DK Explicit, Sidney, Sherpa, and Witt. During the second year, the experiment was extended to include the cultivars: Andromeda, Arabella, Dozzen, DK Explicit, Sidney, Sherpa, and Witt. During the first year of the experiment, pollinator visitation was observed on winter oilseed rape cultivars: Artoga, DK Explicit, Sidney, Sherpa, and Witt. During the second year, the experiment was extended to include the cultivars: Andromeda, Arabella, Dozzen, DK Explicit, Sidney, Sherpa, and Witt. During the first year of the experiment, pollinator visitation was observed on winter oilseed rape cultivars: Artoga, DK Explicit, Sidney, Sherpa, and Witt. During the second year, the experiment was extended to include the cultivars: Andromeda, Arabella, Dozzen, DK Explicit, Sidney, Sherpa, and Witt.

To summarize honey bee and bumble bee visitation data from each cultivar during the blooming period, a visitation rate (VR) index was calculated. Expressed in percentage, it represents the total number of pollinator visits in the cultivar during the blooming period relative to the total number of visits in the whole trial. This index is calculated as follows:

\[
VR = \frac{\sum_{i} n_1}{\sum_{i+y} n_1 + n_2 + n_x} \times 100
\]

Where: \( t \) – number of observations; \( n_x \) – number of observed pollinators on cultivar; \( y \) – number of cultivars in each trail year.
Monitoring of pollinator visitation. In cultivar experiment, pollinator visitation assessments were conducted according to the same methodology as used by Stejskalová et al. (2018), during days with the following conditions for pollinators flight: air temperature higher than 20°C; very light or no wind; and, no precipitation. Pollinator visitations were counted and recorded from an area of 2.1 m² from the edge of single plots of flowering oilseed rape for 20 s. Pollinator visitation observations for cultivar experiments started with the beginning of the flowering of the first cultivar until the end of the flowering of the last cultivar. Visitation data were collected from 24 April to 20 May 2015 (27 observations), from 20 April to 20 May 2016 (55 observations) and from 4 to 26 May 2017 (77 observations).

Statistical analysis. The results of the pollinator visitation on cultivars of oilseed rape were statistically evaluated by the variance analysis method. A more detailed evaluation was performed with some non-parametric tests at the level of significance \( \alpha \leq 0.05 \) (tests are deeply described in results). The analysis was conducted in Statistica 12 CZ software (Palo Alto, USA).

RESULTS AND DISCUSSION

In small-plot field experiments with winter oilseed rape, the differences in the numbers of honey bees and bumble bees were observed between types of varieties and cultivars with different flower colors. The differences in the number of visits by honey bees and bumble bees are shown in Table 2. The total number of pollinator visits recorded in this experiment was 6864; of these, 68.3% were from honey bees \((n = 4691)\) and 31.7% from bumble bees \((n = 2173)\). Thus, in the oilseed rape, the honey bee appears to be the main pollinator. However, Stanley et al. (2013) refute this statement, saying that bumble bees were the main oilseed rape pollinator in Ireland in the field experiments. But compared to the Czech Republic, Ireland is one of the countries with the lowest number of colonies per km².

Factors affecting the visitation of oilseed rape by pollinators. The differences in pollinator visitation in observed years are mainly caused by the date of oilseed rape and fruit tree blooming. When flowering at the same time, fruit trees are more attractive to honey bees, or the dandelions may also be competitive, as Free (1968) states. The pollinator traffic in oilseed rape is also influenced by the course of weather, especially temperature, precipitation, and wind strength. Thus, the number of days optimal for pollinator flight varies each year (Farkas 2008). This is because bumble bees can fly at lower temperatures and in more adverse weather conditions than honey bees (Tuell and Isaacs 2010). Farkas (2008) also mentions nectarodity as an important factor, which makes the cultivars more attractive to honey bees. The author studied the production of nectar and sugar composition of four cultivars of oilseed rape (Baldur, Bekalb, Catonic, and Colombo). It was found that weather conditions had a significant effect on nectar production. Bees visited plants only in sunny and dry weather, either because the concentration of sugar in nectar was more attractive to them, or because the temperature conditions were more favorable to honey bee activity. Blažytė-Čereškienė et al. (2010) state that honey bees can discriminate among rape genetic lines that give more or less reward and adapt.
the number of their visits to the nectar secretion rate. In their study, the oilseed rape cultivars (SW Savann, Ural) were not similar in attractiveness or access to nectar to honey bees; therefore, insects visited cv. SW Savann more often than cv. Ural. Veselý et al. (2009) add that the production of nectar varies from year to year. Nectar production is most influenced by the physiological state of the plant (supply of water, nutrients, etc.). Also, according to beekeepers’ observations, oilseed rape cultivars produce more nectar in areas where soils are well supplied with moisture and at temperatures around 22°C. Danka et al. (2006) report that the total sugar content of oilseed rape nectar varies during the day and flowering. The authors measured higher values in the afternoon compared to the morning. Pernal and Currie (1998) also measured higher values in the first two weeks of oilseed rape blooming, compared to the last two weeks.

**Cultivar as a monitored factor.** In 2015, DK Explicit was the most visited cultivar by honey bees. Bee visitation rate on this cultivar reached VR 142%. It was found that among the yellow-flowering cultivars, the lowest attendance rate was on cv. Artoga (VR 104%). However, the lowest statistically significant differences in visitation rate were on the white flowering cultivar, Witt (VR 20%). In 2016 and 2017 the larger number of cultivars was evaluated. The most visited cultivar in 2016 was the Dozzen cultivar (VR 134%). The lowest visitation of honey bees was found in cv. Arabella (VR 67%) and cv. DK Exprit (VR 72%). Statistically significant differences were found in 2016 only between the cultivars with the highest attendance, Dozzen, and the lowest attendance cultivars, Arabella and DK Exprit. In 2017, the most visited cultivar was Sherpa (VR 132%). The lowest honey bee visitation was found in the Andromeda (VR 55%), Artoga (VR 75%), and Witt (VR 77%) cultivars. In 2017, there was no statistically significant difference in bee attendance among any tested cultivars. The effect of oilseed rape cultivars on honey bee attendance is therefore low. Ouvrard and Jacquemar (2019) report that rapeseed cultivars are not stigmatized in relation to pollinators due to the rapid variation of the cultivar. However, Blažytė-Čereškienė et al. (2010) examined the relationship between honey bee density and flower density on 2 rape cultivars and found that honey bee density in the investigated oilseed rape cultivars was positively correlated with flower density. Thus, an increase in flowering intensity was followed by an increase in honey bee density in both rape cultivars and, as well, conversely.
In 2015, the most visited oilseed rape cultivar by bumble bees was cv. Sherpa (VR 146%). The absolutely least attractive cultivar was the white flowering cv. Witt (VR 23%). Statistically significant differences in bumble bee attendance were found only between the cv. Witt and the cvs. DK Explicit, Sherpa, and Sidney. In 2016 and 2017, the same as in the case of honey bees, the larger number of cultivars was evaluated. The visitation of bumble bees on the experimental plot in 2016 was very low. The most visited cultivar was cv. Artoga (VR 375%). The absolutely least attractive cultivar was the white flowering cv. Witt (VR 23%). Statistically significant differences in bumble bee attendance were found in 2016 between the most visited cv. Artoga and other cultivars except cvs. DK Exprit and Mentor. In 2017, the most visited cultivar by bumble bees was cv. DK Exception (VR 143%). The lowest bumble bee attendance was found in the cv. Sherpa (73% of the average attendance) and cv. DK Explicit (77.3%). In 2017 there was no statistically significant difference in the visitation of bumble bees among tested cultivars. The influence of oilseed rape cultivars on bumble bees visitation is low.

**Type of cultivar as a monitored factor.** In our study, the influence of the cultivation of hybrid and line cultivars on pollinator visitation was also studied (Figure 1a,b). Ouvrard and Jacquemar (2019) point out that the type of cultivar is one of the factors influencing pollinators in their selection. In 2015, hybrid cultivars were visited by honey bees by 77% more than line cultivars, and by 63% in case of bumble bees. This difference was statistically significant in both groups. A large difference in visitation was mainly caused by the white-flowering cv. Witt, which bloomed in pure white that year and showed a low visitation of pollinator. In the following years 2016 and 2017, the visitation of hybrid and line cultivars was almost balanced, and there was no statistically significant difference in either of the studied pollinator groups.

**Bloom color as a monitored factor.** In all monitored years, the number of pollinators in oilseed rape

![Figure 1. Average number of honey and bumble bees per observation on different types of oilseed rape cultivars and color blooming oilseed rape cultivars. The statistic evaluation of this is shown by letters above columns for each year separately. Columns with the same letter do not differ in distribution significantly as based on the Mann-Whitney U-Test at significance level 0.05](image-url)
On visitation for both pollinator groups is the color of the flower. The white flowering cv. Witt has a different VR each year, which fluctuates strongly in relation to the change in the hue of the flower. This knowledge should draw attention to the fact that any other cultivars with changed color of the flower should always be checked for the perception of this change by pollinators.

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