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The Response of Insects and Weeds within the Crop to Variation in Sowing Density of Canola

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Abstract: The relationships between weeds and insects in canola stands with different seeding rates are not fully understood. Varying seeding rates in canola crops can create different conditions that affect both weed and insect populations and their interactions. The aim of this work was to determine the response of weeds and insects of selected taxa to different densities of canola stand densities and to clarify the interactions between weeds and insects in canola stands. The field experiment was conducted on a plot located in the cadastral area of the municipality of Pěnčín (Moravia, Czech Republic). The results show that a reduced canola sowing rate of oilseed rape leads to increased weed infestation, which is dominated by one taxon (*Papaver rhoeas* L.). The increase in weed infestation of canola stands is not reflected in an increase in the diversity of captured insects. Increased canola seeding rate improves weed suppression but increases the number of canola pest insects. A higher number of plants and more canola biomass increase the food supply and, thus, make the stand more attractive to canola pests. The taxon *Brassicogethes aeneus* dominated the pests species spectrum. Changing the seeding rate of canola results in a response in weed and insect populations. The standard recommended seeding rate is optimal in terms of competitive suppression of weeds and the occurrence of pests and trapped insects. Increasing or decreasing the seeding rate of rapeseed does not bring any benefits in terms of pest regulation or biodiversity. However, the results obtained indicate an interesting weed–insect interaction in the conditions of canola stands.

Keywords: *Brassica napus Napus Group*; kompetice; competition; weed vegetation; insects; organism interactions

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1. Introduction

Crop productivity is influenced by several biotic and abiotic factors. Weeds deplete the limited resources essential for crop growth. The presence of weeds not only causes large yield losses, but also increases production costs and reduces production quality. Crop–weed competition is influenced by three main factors—weed emergence time, weed density and weed species. Weeds that emerge before or at the same time as the crop are more competitive than weeds that emerge after the crop is established [1].

Crop seeding density is determined by the distance between sown seeds, which affects crop competitiveness against weeds [2]. Narrow-row crops are sown in rows 12.5 cm apart. This spacing allows the crop to achieve a higher yield and lower weeding compared to

wider spacings [3,4]. An increase in crop density can lead to competition for resources such as sunlight, water and nutrients, which suppresses weed growth [5]. Primarily well-established and fast-growing crops can limit the weed development and growth due to competition for resources [6]. The competitiveness of narrow-row crops against weeds is also determined by their ability to form offshoots, which can increase the stand density [7,8].

While a high density of narrow-row crops can reduce individual grain growth due to increased competition among plants, slight variations in spacing may not necessarily affect the overall yield per acre, as the increased plant density can improve weed suppression and overall crop productivity [9]. The intensity and duration of crop–weed competition determines the magnitude of crop yield losses [10]. While high weed density generally affects crop yields negatively [11], a certain amount of weeds can exist in crops without causing substantial yield losses. This indicates that a complete weed control may not be necessary to achieve high yields [12,13]. At similar densities, distinct weed species may differ in their ability to compete with crop plants due to differences in their growth habit and allelopathic effects on crop germination and growth. In arid regions, perennial weeds such as *Cirsium arvense* or *Convolvulus arvensis* are more competitive than annual weeds thanks to their deep roots, early proliferation and dense shoot growth [1]. Weeds benefit from a reduction in crop seeding density due to a decrease in competition during the early growing season [9]. However, adjusting the stand density, to a certain extent, does not affect crop yield but affects weed vegetation, which is important for insects such as bumblebees [14]. The presence of weeds in fields has been demonstrated to contribute to the abundance of flower-visiting insects [15–17]. Flowering weed species are essential for wild pollinators such as Syrphidae [15] or solitary bees [18]. Weed species that provide abundant flowers contribute to specific plant–insect interactions, primarily due to the high availability and quality of their nectar and pollen [19–22]. Weed pollen and nectar are critical food components for many invertebrate species [23]. For example, the longevity and fecundity of insect parasitoids are considerably increased when nectar is available [24,25]. It has been proven that certain species of beneficial insects and parasitoids, which regulate pest populations in cultivated fields, use the nectar and pollen resources [26].

The relationship between weeds and crops is complex; variations in weed abundance can have unpredictable effects on crop production, sometimes resulting in reduced yields [27,28]. However, weeds also play a functional role in seed production by providing a food source for animal populations, thereby contributing to the maintenance of those populations [29,30]. Weed seeds are consumed by ground beetles of the *Harpalus genus*, which help reduce unwanted weeds [31,32]. Annual weed biomass serves as a food source for soil-dwelling invertebrates, including earthworms [33]. Alternative weed management promotes a trade-off between maintaining insect populations, crop yields and income for farmers [34]. The protection of wild plants at field edges and the promotion of weed diversity in fields may be a suitable strategy to enhance populations of pollinating insects in agricultural landscapes [35–38].

The decline of arthropods is a pressing global issue, often highlighted in the context of the global 'biodiversity crisis' and the 'insect apocalypse'. Studies indicate that arthropods have declined significantly not only in biomass, but also in abundance and species richness in various ecosystems. This decline in diversity suggests that species may be going extinct in many regions. The primary causes of arthropod declines are not fully understood, but may be related to landscape-level changes, including the increasing proportion of agricultural land, intensification of crop production and increased use of more potent insecticides. These factors call for a paradigm shift in land use policies at national and international levels. In addition, the composition of the landscape plays a critical role in the life cycles of insect pests, particularly in non-crop and semi-natural habitats. Extensively managed perennial non-crop habitats such as forest margins, grasslands, permanent pastures and field margins have been shown to provide overwintering habitats for agricultural pests and other insect species [39–44].

The sustainable regulation of insect pest populations may be supported by the configuration of agricultural landscape. The prevalence of pests can be reduced by limiting their access to the resources needed for completion of their life cycle, e.g., the availability of host plants, alternative hosts, and overwintering sites [45]. The current agricultural landscape is the result of land-use transformations aimed at labour and low-cost agricultural production rather than pest control [46].

Canola (*Brassica napus*) is commonly grown in several temperate regions around the world in systems aiming to produce weed-free monocultures [47–49]. The diversity of microhabitats in crop stands that weeds help establish has the potential to enhance biological control of pests [50]. The study of insect–weed interactions can provide useful insight into the perspective of biological regulation, i.e., weed control with the use of natural enemies [51]. Finding a compromise between weed management and crop yield provides advantages in terms of beneficial insect occurrence and canola pest predation, which is the basis for optimal integrated crop management in regions [50].

The interactions between weeds and insects within canola stands at different seeding rates are not fully understood. Different seeding rates can create different conditions that influence weed populations, insect communities, and their interactions. The objectives of this study were to (i) evaluate the response of weed species to varying canola stand densities, (ii) evaluate the response of selected insect species to varying canola stand densities and (iii) to elucidate weed–insect interactions under these varying conditions.

2. Materials and Methods

2.1. Study Area

The field trial was conducted on a plot situated within the cadastral territory of the municipality of Pěnčín (Moravia, Czech Republic). The average altitude of the terrain is 311 m (GPS 49.5703928 N, 17.0211019 E). The soil type is classified as modal brown soil, and the soil-forming substrate is loess and loess clay. The soil comprises deep to medium-deep, loamy-sandy to clay-loamy soils. The inclination of the land is 3°, corresponding to a slight slope. The area has an average annual temperature of 8.1 °C, with July being the hottest month of the year, with an average daily temperature of 18.3 °C. In contrast, January is the coldest month, with an average daily temperature of 2.1 °C. The distribution of rainfall during the growing season was uneven. In terms of precipitation, July was the month with the highest precipitation (66 mm), while February was the month with the lowest precipitation (23 mm). The total annual precipitation was 530 mm.

2.2. Methodology of a Field Trial with Canola Competitiveness

The stands of canola crops were sown in 2 growing seasons—2022/2023 and 2023/2024. The pre-crop was always winter wheat. The cultivation technology was identical in both years. The canola was sown on 1 September 2022 and 5 September 2023. The hybrid variety RGT Trezzor was used. This variety, registered in the Czech Republic at the end of 2017, has proven to be highly adaptable to the variable climatic conditions. The variety copes well with drier locations and belongs to the varieties with an excellent health status. The advantage of this mid-early variety is its high resistance to wintering. It does not grow in autumn and has a medium-late development in spring. Medium-tall plants have an above-average lodging resistance. The recommended sowing rate is 40 to 50 seeds per m^2.

The field trial was designed as a pilot project. The size of one plot was 12 × 144 m. A field trial with diverse competitive abilities of canola stands had 5 variants with different sowing rates: (i) 25 seeded canola plants per 1 m^2 (**SU 0.50**), (ii) 37 seeded canola plants per 1 m^2 (**SU 0.75**), (iii) 25 seeded canola plants per 1 m^2 (**SU 1.00**), (iv) 60 seeded canola plants per 1 m^2 (**SU 1.20**) and (v) 75 seeded canola plants per 1 m^2 (**SU 1.50**). There were 500,000 germinating canola seeds in each sowing unit (SU), equivalent to 50 canola plants sown per 1 m2. There were 2 plots (12 × 144 m) for each SU variety. There were 10 plots (12 × 144 m) for the whole experiment. The plots were arranged in 2 blocks of 5 SU variants each. Individual SU variants were placed side by side in a random order, always so that

the same variants were not adjacent to each other. These plots created an environment with different canola structure in which weed and insect abundance was assessed.

2.3. Evaluation Methodology of Weed and Insect

In each season, 4 evaluation plots were selected for each of the trial variants. These evaluation areas were placed in the centre of the experimental plot at a minimum distance of 10 m from each other. Weed evaluation plots were 1 m^2 in size. Weed species were identified within each area and the number of plants of each weed species was determined. Taxonomic nomenclature of the plants follows Kaplan et al. [52]. The evaluation was carried out in April each year.

Möricke traps, used to catch insects, were placed in close proximity to the weed evaluation areas. The evaluation date was in April of each year, as was the weed evaluation. Möricke traps belong to the group of optical traps. According to the method of capturing insects, optical traps are divided into glue plates and Möricke traps. These traps are filled with water to ¾ of their volume. To reduce the surface tension of the water, a detergent preparation is dripped into each trap. These traps are attractive not only to pests, but also to Hymenoptera and other groups of insects. The contents of the traps were then poured through a thick sieve, and the insects were preserved in 70% alcohol and prepared for species determination. Species determination was carried out in the laboratory using a microscope.

2.4. Statistical Data Processing

The date of the occurrence of weeds and captured insects from individual observations were used for statistical processing. Linear regression was used to process the number of species and number of individuals of weeds, pests and non-pest insects. The data from 2 evaluation years and from 5 variants of canola stand density were evaluated using multivariate analyses of ecological data. The initial analysis was conducted using detrended correspondence analysis (DCA). The aim of DCA is to select the most appropriate subsequent analysis and its result is the length of the gradient. The response data for the evaluation of weeds and insects in different canola seeding conditions were compositional and had a gradient 2.5 SD units long, so linear method was recommended. Based on the output generated by the Canoco 5.0 software and the methodological procedure, redundancy analysis (RDA) was selected as the most appropriate analytical approach. The following settings were used: Computed axes 4, Detrending None, Hybrid analysis not performed, Response data (species) transformation log (Log transformation formula: $Y' = 1 \times Y + 1$), Center and standardise by species yes. The statistical significance of the data was assessed using the Monte Carlo test with 999 permutations. All multivariate analyses and necessary calculations were performed using the Canoco 5.0 software [53].

3. Results

A total of 10 taxa of canola pests, nine taxa of other insects and 18 weed taxa were identified in canola stands with different competitive abilities. The numbers of species and individuals of canola pests, other taxa of insects and weeds are shown in Figures 1 and 2.

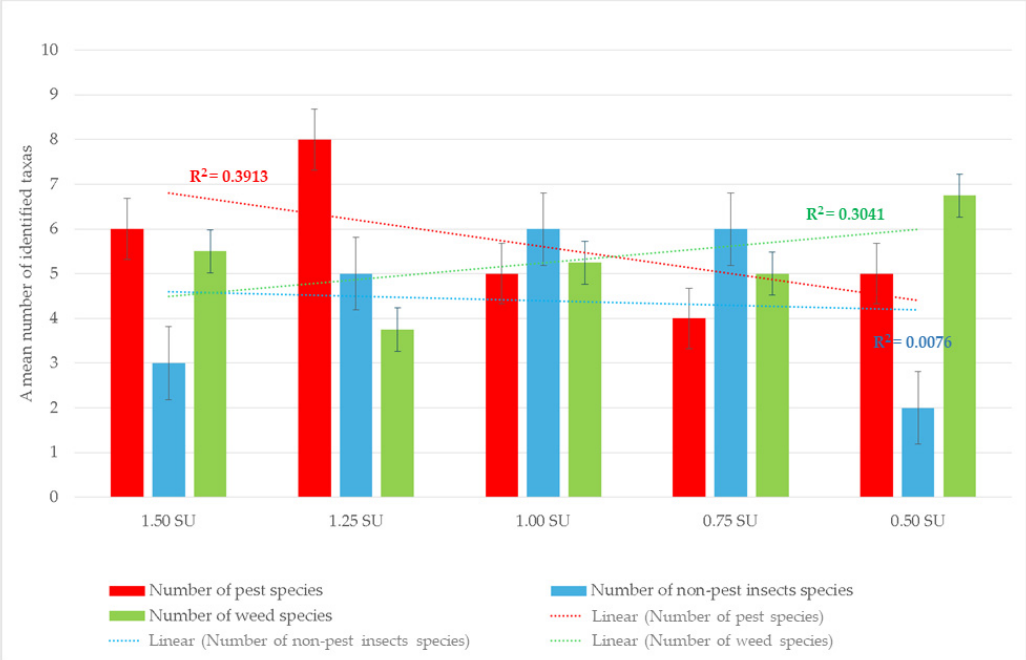


Figure 1. Number of insect and weed species under conditions of diverse canola seeding rate (the errors bars SE, N = 8).

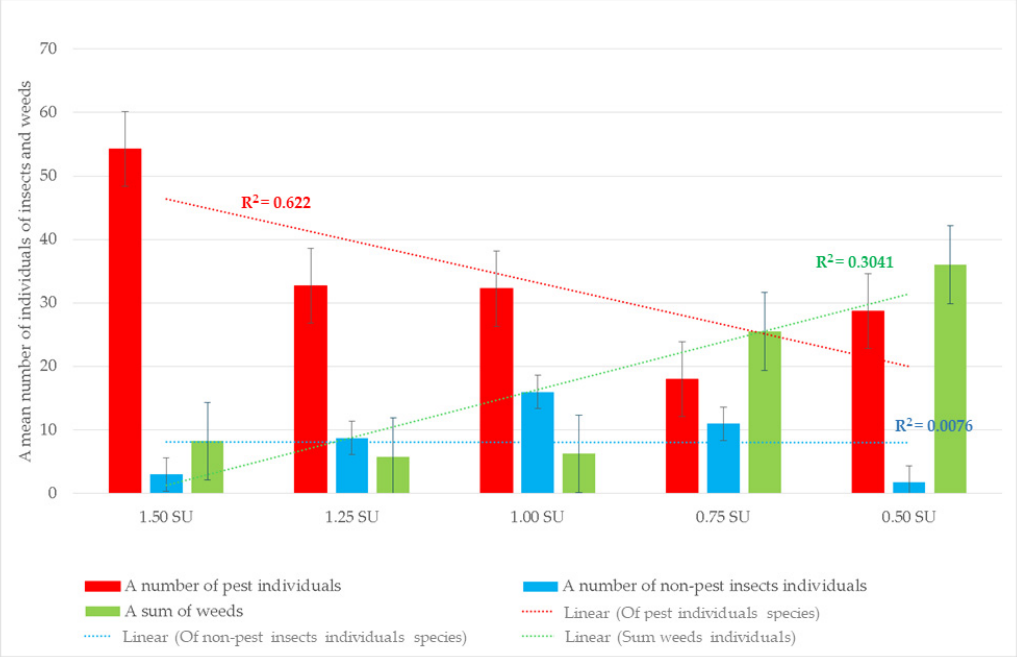


Figure 2. Mean number of individuals of insects and weeds under conditions of diverse canola seeding rate (the errors bars SE, N = 8).

The following taxa were included among canola pests: *Brassicogethes aeneus* (Fabricius, 1775; individuals, 340; 51%), *Phyllotreta atra* (Fabricius, 1775; individuals, 108; 16%), *Dasineura brassicae* (Winnertz, 1853; individuals, 83; 13%), *Delia radicum* (Linnaeus, 1758; individuals, 82; 12%), *Ceutorhynchus pallidactylus* (Marsham, 1802; individuals, 19; 3%), *Brassicogethes viridescens* (Fabricius, 1787; individuals, 12; 2%), *Phyllotreta undulata* (Kutschera, 1860; individuals, 12; 2%), *Oulema melanopus* (Linnaeus, 1758; individuals, 4; 1%), *Psylliodes chrysocephalus* (Linnaeus, 1758; individuals, 2; 0%) and *Meligethes atratus* (Olivier, 1790; individuals, 2; 0%). The representation of individual taxa is shown in Figure 3.

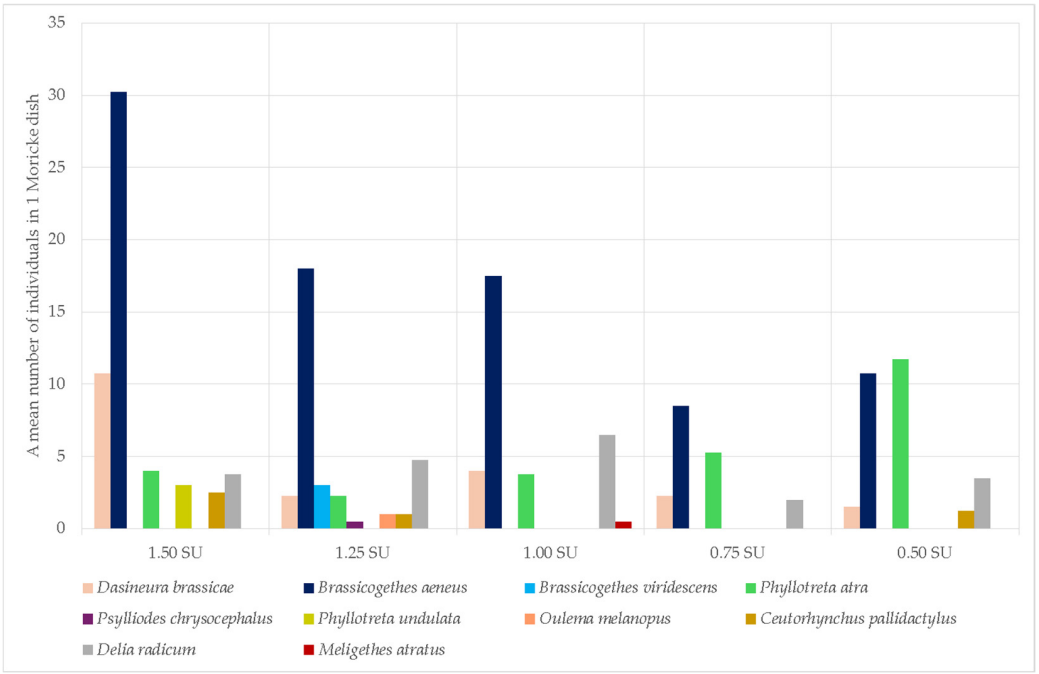


Figure 3. Representation of individual pest taxa under conditions of diverse canola seeding rate.

The following other insect taxa caught in canola stands were as follows: *Nematocera* (Duméril, 1805; individuals, 67; 41%), *Tersilochus* (Holmgren, 1859; individuals, 38; 23%), *Diptera* (Linnaeus, 1758; individuals, 18; 11%), *Staphylinidae* (Latreille, 1802; individuals, 15; 9%), *Macrosteles laevis* (Ribaut, 1927; individuals, 7; 4%), *Psammotettix alienus* (Dahlbom, 1850; individuals, 5; 3%), *Cotesia glomerata* (Linnaeus, 1758; individuals, 5; 3%), *Atomaria* (Stephens, 1829; individuals, 4; 2%) and *Chlorops pumilionis* (Bjerkander, 1778; individuals, 3; 2%). The representation of individual taxa is depicted in Figure 4.

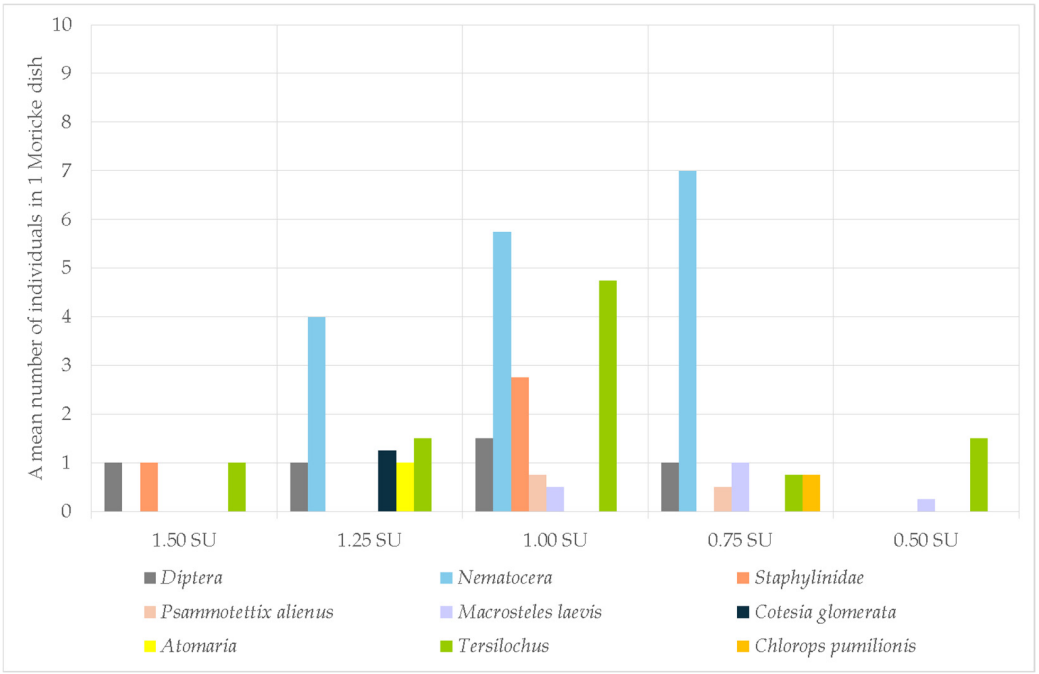


Figure 4. Representation of individual other insect taxa under conditions of diverse canola seeding rates.

The following weed taxa were found in canola stands: *Papaver rhoeas* (individuals, 142; 41%), *Triticum aestivum* (individuals, 43; 12%), *Viola arvensis* (individuals, 37; 11%), *Veronica persica* (individuals, 24; 7%), *Chenopodium album* (individuals, 22; 6%), *Veronica polita* (individuals, 19; 5%), *Tripleurospermum inodorum* (individuals, 12; 3%), *Fallopia convolvulus* (individuals, 10; 3%), *Veronica hederifolia* (individuals, 9; 3%), *Stellaria media* (individuals, 6; 2%), *Lamium amplexicaule* (individuals, 6; 2%), *Thlaspi arvense* (individuals, 5; 1%), *Capsella bursa-pastoris* (individuals, 4; 1%), *Polygonum aviculare* (individuals, 4; 1%), *Cirsium arvense* (individuals, 3; 2%), *Sonchus arvensis* (individuals, 1; 0%), *Fumaria officinalis* (individuals, 1; 0%) and *Descurainia sophia* (individuals, 1; 0%). The representation of individual taxa is illustrated in Figure 5.

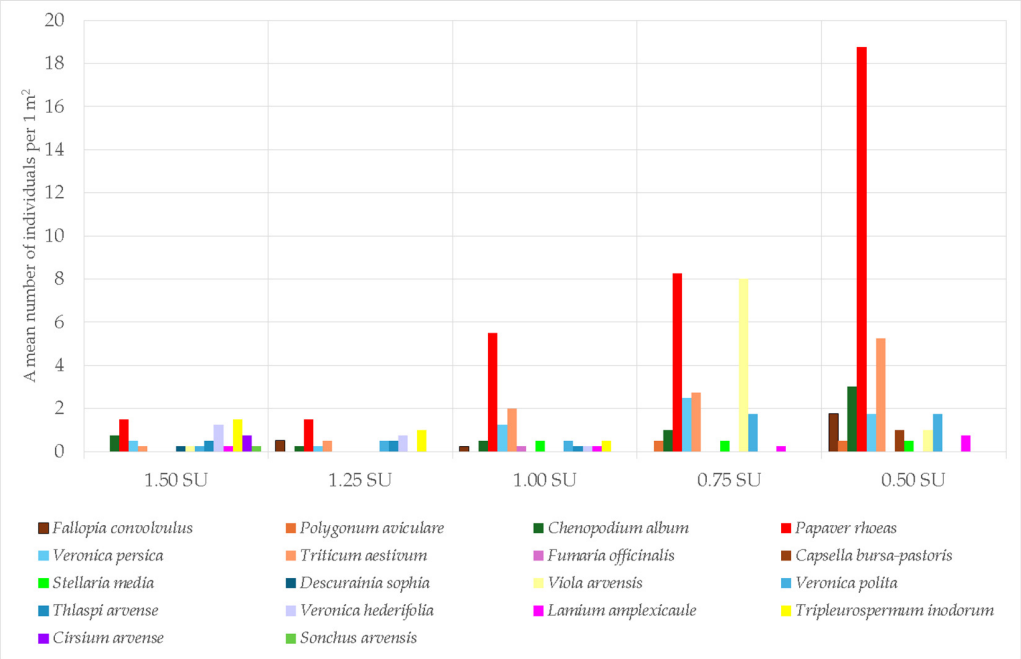


Figure 5. Representation of individual weed taxa under conditions of diverse canola seeding rates.

The relationships between canola stand density, the occurrence of selected insect and weed taxa from the two-year-long evaluation were processed by RDA analysis. The results are presented in Figure 6.

On the basis of the statistically validated findings, the identified insect and weed taxa can be divided into groups according to their relationship to the density of canola stands. Weed and insect species were divided into groups according to the relationships shown by the RDA analysis between weed and insect species under the conditions of different canola stands. The groups of taxa are shown in Table 1.

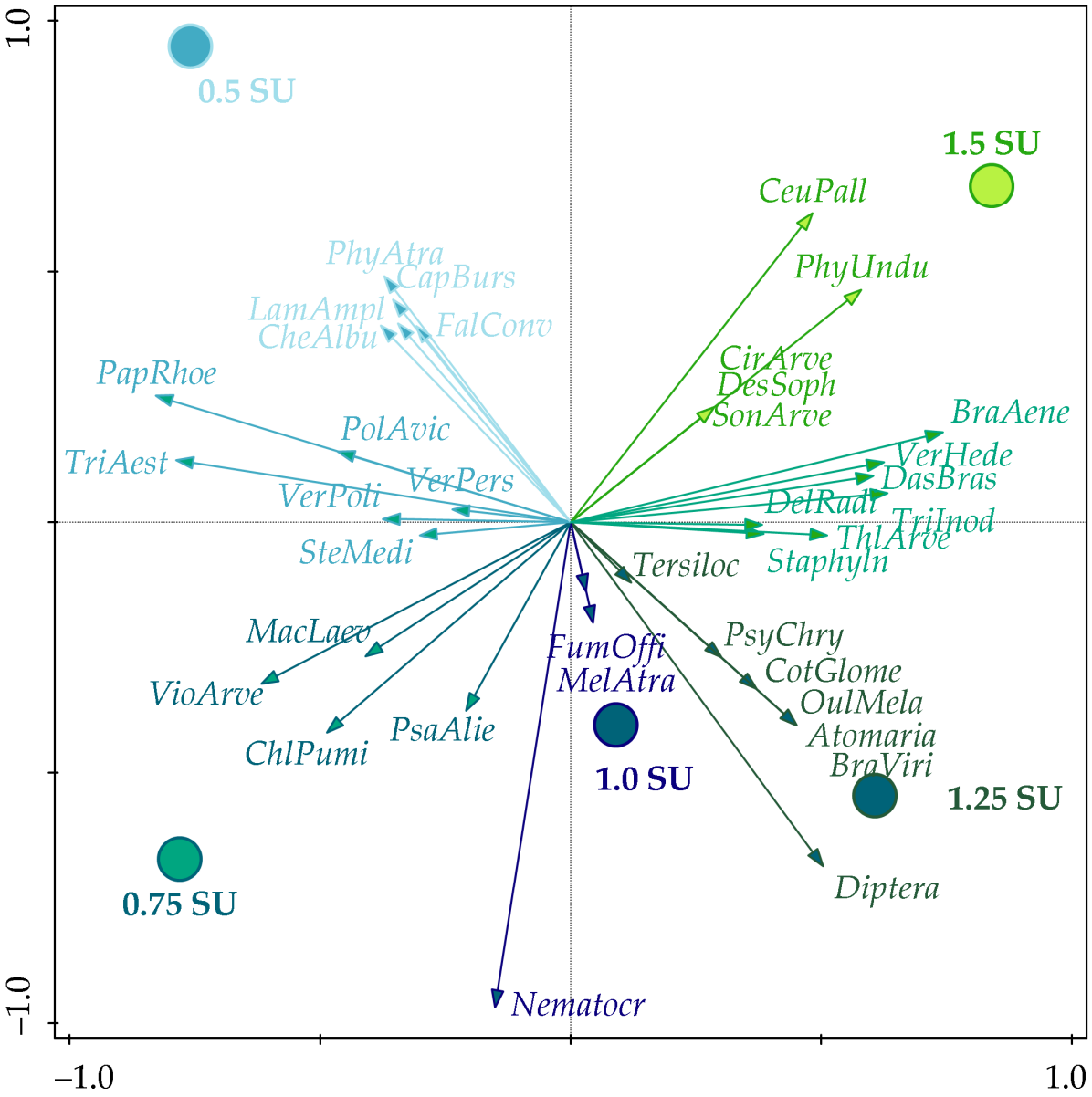


Figure 6. Relationship between canola stand density and insect and weed taxa (result RDA; figure: total explained variability = 48.8%, F-ratio = 5.5, *p*-value = 0.001; Explanatory notes of abbreviations: *Atomaria (Atomaria), Brassicogethes aeneus (BraAene), Brassicogethes viridescens (BraViri), Capsella bursa-pastoris (CapBurs), Ceutorhynchus pallidactylus (CeuPall), Cirsium arvense (CirArve), Cotesia glomerata (CotGlome), Dasineura brassicae (DasBras), Delia radicum (DelRadi), Descurainia sophia (DesSoph), Diptera (Diptera), Fallopia convolvulus (FalConv), Fumaria officinalis (FumOffi), Chenopodium album (CheAlbu), Chlorops pumilionis (ChlPumi), Lamium amplexicaule (LamAmpl), Macrosteles laevis (MacLaev), Meligethes atratus (MelAtra), Nematocera (Nematocera), Oulema melanopus (OulMela), Papaver rhoeas (PapRhoe), Phyllotreta atra (PhyAtra), Phyllotreta undulata (PhyUndu), Polygonum aviculare (PolAvic), Psammotettix alienus (PsaAlie), Psylliodes chrysocephalus (PsyChry), Sonchus arvensis (SonArve), Staphylinidae (Staphylinidae), Stellaria media (SteMedi), Tersilochus (Tersilochus), Thlaspi arvense (ThlArve), Triticum aestivum (TriAest), Tripleurospermum inodorum (TriInod), Veronica hederifolia (VerHede), Veronica persica (VerPers), Veronica polita (VerPoli), Viola arvensis (VioArve).*

Table 1. Groups of insect and weed taxa according to their relationship to the density of canola stands based on the results of RDA analysis.

Variants of Canola Stands	Insect Taxa	Weed Taxa
1.50 seeding rate	***Ceutorhynchus pallidactylus, Phyllotreta undulata***	***Cirsium arvense, Descurainia sophia, Sonchus arvensis,***
1.50 seeding rate and 1.25 seeding rate	*Brassicogethes aeneus, Dasineura brassicae, Delia radicum, Staphylinidae,*	*Thlaspi arvense, Tripleurospermum inodorum, Veronica hederifolia*
1.25 seeding rate	***Atomaria, Brassicogethes viridescens, Cotesia glomerata, Diptera, Oulema melanopus, Psylliodes chrysocephalus, Tersilochus***	**–**
1.00 seeding rate	*Meligethes atratus, Nematocera,*	*Fumaria officinalis*
0.75 seeding rate	***Chlorops pumilionis, Macrosteles laevis, Psammotettix alienus,***	***Viola arvensis***
0.75 seeding rate and 0.50 seeding rate	–	*Papaver rhoeas, Polygonum aviculare, Triticum aestivum, Stellaria media, Veronica persica, Veronica polita*
0.50 seeding rate	***Phyllotreta atra***	***Capsella bursa-pastoris, Chenopodium album, Fallopia convolvulus, Lamium amplexicaule***

4. Discussion

Vegetation provides diverse niches (microhabitats) that offer different opportunities to animals including insects in terms of food supply or shelter from predators [54,55]. A modification of the canola seeding rate results in alterations to the conditions within the stand, which, in turn, elicit responses in the species composition and abundance of insect and weed populations. However, the reactions of selected groups of organisms are different. The results indicate a trend that both the population abundance and the number of taxa associated with canola pests increase with an elevated sowing rate. The insect taxa that act as canola pests thrive better in canola stands with higher seeding rates. The species *Brassicogethes aeneus* is predominantly dominant, and its population size decreases with decreasing canola seeding rate. Higher concentrations of canola plants create a higher food supply, which is reflected in a higher abundance of canola pests. According to Obermeier et al. [56] and Hervé et al. [57], *B. aeneus* belongs to plant pests of the *Brassicaceae* family. According to Juhel et al. [58], *B. aeneus* has an average flying range of 1.2 km, so it can be assumed that more food in denser canola vegetation attracted individuals from the surrounding area. *B. aeneus* is one of the most important pests of spring and winter canola in the Czech Republic, and its populations are highly resistant to the pyrethroid lambda-cyhalothrin [59,60].

On the other hand, taxa of pests preferring sparse canola stands were also identified. These include *Phyllotreta atra*. Boetzl et al. [61] points out the higher occurrence of this taxon in sparser stands on the edges of fields, which may be related to its lower ability to move in the landscape. This is also confirmed by our results, indicating that *Phyllotreta atra* prefers sparse stands to dense canola stands.

Other insect taxa, which are not directly linked to the presence of canola as a food source, were the most numerous and the most diverse in species in stands with a standard sowing rate (1.00 SU). The most numerous taxa were *Nematocera* and *Tersilochus*. The presence of these taxa may be associated with a higher representation of weed taxa that do not have a dominant representation in canola stands. According to Martin et al. [62] and Boetzl et al. [63], optimal crop stand density can be favourable for natural enemy populations and also benefits natural control of crop pests. This phenomenon is particularly noticeable at the edges of plots, where a high abundance of natural enemies is maintained. These land edges function as buffer zones.

The diverse seeding rate also had an impact on the weed vegetation. In contrast to the observed patterns in pest populations, the opposite trend was identified. According to the established trend, the number of weeds and the number of taxa increased with the decreasing canola seeding rate. Canola stands with a reduced seeding rate had the highest species diversity and abundance of weeds. It is evident that the relationships between canola and weeds are markedly competitive. The species spectrum of canola stands is

always made up of one dominant taxon. The dominant position is occupied by canola in the sowing variants 1.50 SU, 1.25 SU and 1.00 SU. *Papaver rhoeas* takes over the dominant position in the 0.75 SU and 0.50 SU variants. As found by Sidemo-Holm et al. [16], reduced seeding density may contribute to the maintenance of flowering weeds as food sources for pollinator communities in agricultural landscapes without negative impacts on crop yield. The results suggest that crop seeding row spacing could be increased without loss of yield while reducing seed costs and benefiting flowering weeds. However, our results do not align with these findings. Vegetation changes can have a negative impact on biodiversity and the number of invertebrate insect species [64].

According to the results of the RDA analysis, similar responses to different canola seeding rates in weed and insect taxa can be observed. Dense stands with the highest seeding rate are convenient to the insect taxa *Ceutorhynchus pallidactylus*, *Phyllotreta undulata Brassicogethes aeneus*, *Dasineura brassicae*, *Delia radicum* and *Staphylinidae* and also to the weed taxa *Cirsium arvense*, *Descurainia sophia*, *Sonchus arvensis*, *Thlaspi arvense*, *Tripleurospermum inodorum* and *Veronica hederifolia*. However, the number of weeds was low due to the high competition with canola. Nevertheless, it can be assumed that the plants of certain weed taxa are a direct source of food (e.g., *Thlaspi arvense*, *Descurainia sophia*) or are a source of pollen and nectar for insects (e.g., *Cirsium arvense*, *Sonchus arvensis*, *Tripleurospermum inodorum*, *Veronica hederifolia*). These specific weed–insect interactions are explained by Hegland and Totland [19], Campbell et al. [20] and Balzan et al. [21] in terms of high availability (flower with flat morphology) and nectar and pollen quality, as demonstrated by the studies on *Tripleurospermum inodorum* [65] and *Cirsium arvense* [66].

The presence of weeds expands the food supply and, thus, supports the abundance of insects in canola stands. As reported by Biesmeijer et al. [30] and Marshall et al. [29], the weed flora plays a functional role in the production of seeds and biomass that serve as a food source for a number of flagship species. Gaigher and Samways [67] found that weed biomass creates structural diversity and supports different arthropod species. Furthermore, the significance of weeds as a source of pollen and nectar is also increasingly highlighted in the scientific literature [17,18,68–71]. Diverse weed communities are very important for hoverflies and solitary bees [12,15,18], but also for parasitoids [24,25] and ladybugs [26]. Maintaining weed diversity in fields is considered a suitable strategy for enhancing pollinating insects in agricultural landscapes [37,72,73]. The decline of insects has been demonstrated to be associated with the loss of food or nesting resources caused by field weeding and the destruction of semi-natural features [18]. The intensification of agriculture has resulted in a significant reduction in abundance and diversity of wild pollinating insects, which are essential for successful plant pollination [74–78].

Sparse canola stands create conditions that are more favourable for weeds but less favourable for insect taxa that have been captured. As posited by Haddad et al. [79], a reduction in the diversity of plant species results in the simplification of insect communities. The change in the spectrum of insects and the decrease in their abundance is likely the result of a reduction in the food supply in the canola stands. In sparse stands, the dominant taxon was *Papaver rhoeas*, which is not attractive to canola pests and other insects caught in the Möricke traps. The only exception is the taxon *Phyllotreta atra*, for which a positive reaction to the presence of *Capsella bursa-pastoris* can be expected.

The development of cost-effective and sustainable weed management strategies requires a comprehensive understanding of the concepts and factors involved in competitive crop–weed interactions [10,80,81]. The implementation of various farming practices, including crop planting dates, competing cultivars, seeding rates, row spacing, nutrient management and irrigation strategies can influence crop–weed competition in favour of crops [82,83]. Human civilization has created and significantly impacted entire ecosystems, allowing the survival of only those plant taxa that use anthropogenic life strategies. These strategies are predominantly observed in agricultural crops, forestry and ornamental species, as well as in weeds [84]. The composition of the vegetation in the fields (crops and weeds) subsequently affects the abundance and species composition of insect populations.

5. Conclusions

The vegetation of canola stands is characterized by a dominant plant taxon, which can be a crop or a weed. The dominance of canola needs to be enhanced by cultivation measures. The cultivation measures also affect insect populations, resulting in the dominance of one taxon and a decrease in the abundance of other taxa.

Our results manifested that the reduced canola seeding rate brings increased weeding dominantly formed by one taxon (*Papaver rhoeas*). The increase in weeding of canola stands was not reflected in the increase in the diversity of caught insect.

An increased canola seeding rate suppresses weeds but increases the number of pest insects of canola. A higher number of plants and more canola biomass increase the food supply and, thus, make the stand more attractive to canola pests. The species spectrum of pests was dominated by one taxon (*Brassicogethes aeneus*).

From the point of view of the populations of other insects, the most favourable conditions are found in stands with a standard canola seeding rate (1.00 SU). A standard seeding rate creates conditions that suppress the dominance of one weed taxon, which allows other taxa to grow and so provide a food source for harmless insect taxa.

The obtained results indicate weed–insect interactions. The taxon *Phyllotreta atra* can be supported by the occurrence of the weed *Capsella bursa-pastoris*. The occurrence of canola pests can be enhanced by the weeds *Thlaspi arvense* and *Descurainia sophia*. Some weed taxa serve as a source of pollen and nectar (*Cirsium arvense*, *Sonchus arvensis*, *Tripleurospermum inodorum* and *Veronica hederifolia*) and support the occurrence of insect taxa.

Modifications to the canola seeding rate have an impact on the weed and insect populations. It has been demonstrated that dense canola stands are more effective at suppressing weeds, although they are also more attractive to canola pests. Conversely, sparse stands create a more favourable environment for weeds and are less attractive to the majority of canola pests. The standard recommended seeding rate is optimal from perspective of competitive suppression of weeds as well as the occurrence of pests and captured insects. An increase or decrease in the canola seeding rate does not bring benefits for the regulation of harmful agents, but neither does it help boost biodiversity. By all means, the obtained results indicate interesting weed–insect interactions in the conditions of canola stands. This issue should be addressed in further research.

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