

Role of refugia plants against *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae) Pest Attack

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ABSTRACT

The Fall Armyworm (*S. frugiperda*) is one of the obstacles in plants corn. Refugia plant is one of the pest control solutions based on the concept of IPM (Integrated Pest Management) that provides a source of feed for natural enemies. The aim of this study to determined the intensity of attack and affected plants caused by *S. frugiperda* using refugia plants as habitat manipulation and known the composition arthropods visit in plants corn with refugia. This research used Non-Factorial Randomized Group Design (RGD) consisting of R0 (Rice plant without refugia / control plant), R1 (Rice plant with refugia red), R2 (Rice plant with yellow refugia), R3 (Rice plant with white refugia), R4 (Plants with rice with refugia white, yellow and red). This studied showed that the level of attack on corn plantations decreased with the refugia treatment, the attack rate was also low in the experimental area. This research had a significant effect on the treatment of R3 (white refugia). meanwhile the composition data of arthropods visited to corn plants show the highest percentage comes from the order Hymenoptera, followed by the orders Diptera, Coleoptera, Hemiptera, Orthoptera, Lepidoptera, and Araneae.

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1. INTRODUCTION

Spodoptera frugiperda is an invasive pest of corn and is polyphagous (Montezano et al., 2018). It attacks corn leaves, causing losses to corn productivity (CABI, 2019). Various prevention and control efforts have been carried out. The use of insecticides is quite high in controlling *Spodoptera frugiperda* pests (Henaish & Elmetwaly, 2021). So it is necessary to make environmentally friendly control efforts (Ardina et al., 2024). Planting refuge crops is one of the control methods based on the Integrated Pest Management (IPM) concept the diversity of refugia plants around crops will be able to support ecological based pest management. Based on research (Sitepu et al., 2018), refugia plants can control the intensity of rice stem borer attack.

The management of flowering plants or refugia in the corn cropping area is able to prevent the presence of pest from laying eggs on the main crop (Ardina et al., 2024). This refugia system can attract beneficial insects such as pollinators, natural enemies to the corn planting area (Rezki et al., 2025). The presence of natural enemies around these plants is expected to reduce the population of *Spodoptera frugiperda* pests. Refugia will be a source of food and shelter for natural enemies when environmental conditions are favorable (Setyadjit & Sukasih, 2015). A balanced ecosystem has an impact on the existence of natural enemies of pests. The existence of various natural

enemies in agricultural ecosystems can reduce pest populations and increase production (Bulawan et al., 2023). Planting peripheral plants in cultivated fields will increase the functional biodiversity of parasitoids and predators compared to a single planting system (Amala & Shivalingaswamy, 2018).

Several studies have proven that the presence of refugia plants in agricultural ecosystems is effective in increasing the diversity of natural enemies in crops. Based on researched (KHAN, 2013) Natural enemies number and density are impacted by the existence of refugia. The presence of ecological density, it is important to ensure that natural enemies can move effectively and control pest populations efficiently (Olsiviana et al., 2024). Plant heterogeneity in agroecosystems is an urgent need in crop intensification efforts. Kenikir and basil flower plants can suppress the population of *P. xylostella* (Mulyadi et al., 2017). In the study (Ardina et al., 2024), refugia treatment with *Turnera subulata* plants showed a higher total population of *Spodoptera frugiperda* egg parasitoids. The use of refugia around the crop area causes more plant diversity. Some refugia plants emit a sharp aroma and also contain active flavonoids, polyphenols, and saponins so that they can be used as insecticidal ingredients (Mulyadi et al., 2017).

The addition of refugia plants in corn planting areas indirectly has a significant effect on the population of *Spodoptera frugiperda* pests. Therefore, this study was conducted to determine the intensity of attack and affected plants caused by *Spodoptera frugiperda* using refugia plants as habitat manipulation and known the composition arthropods visit in plant corn with refugia. this study was conducted using various refuge plants such as *Zinnia elegans*, *Turnera subulata*, and *Melanpodium paludosami* planted around corn plants. Based on this, the effectiveness of various types of refuge plants against the level of damage and intensity of *S. frugiperda* pest attacks was tested. This research can help farmers improve crop yields, reduce losses due to pest attacks, and enhance the effectiveness of natural enemies in controlling pests, especially *Spodoptera frugiperda*, in a natural and sustainable manner.

2. RESEARCH METHOD

2.1 Study site and time

The research was conducted in Juni 2022- December 2022 in the area of corn cultivation of farmers in Desa Saentis, Kec. Percut Sei Tuan, Deli Serdang.

2.2 Research materials and tool

The maize crop used in this research are Pertiwi-3 varieties, while the refugia flower seeds were small sunflower (*Melanpodium paludosumi*), kenikir (*Zinnia elegans*), and *Turnera subulata*. This study also use compost fertilizer, NPK Phonska fertilizer, KCl, urea. The tools used in this research were hoe, hand sprayer, label apper, brush, digital camera, etc.

2.3 Procedure

This study was performed using non-factorial randomized block design (RGD), consisting of 5 treatments with 5 replications: R0 (maize plants without refugia/ control), R1 (maize plants and red refugia) (*Zinnia elegans*), R2 (Maize plants with yellow refugia) (*Melanpodium paludosumi*), R3 (Maize plants with white refugia) (*Turnera subulata*), R4 (Maize plants with red, yellow and white refugia).

Maize seeds were planted with a spacing of 70 cm x 20 cm on plots 5.6 meters in length and 2.5 meters in width. The gap between each block was set at 5 meters, with a total of 25 plots and 80 plants per plot. The total population of the maize plants were 1950 plants. Then, maize plants were observed for growth until data collection was complete.

2.4 Research implementation

The research was initiated by clearing up the land and forming the plots. The plots were then planted with refugia flowers. When refugia plants started to bloom, maize seeds were planted as determined. Fertilizers were applied based on the recommended dosage. Plant maintenace starts with watering the plants, replanting, weeding, and fertilizing the plants. These activities are carried out until the corn plants enter the reproductive period.

2.5 Percentage of plants infested with *Spodoptera frugiperda*

Observations were made 7 days after planting (DAP) at 5-day intervals until the corn was 45 days old. Calculated with the formula (Kementan, 2018):

$$N = \sum \frac{nA}{nA+nB} \times 100\%$$

N = percentage of plants infested with *Spodoptera frugiperda*

nA = Number of plants infested

nB = Number of plants are not infested

2.6 percentage of attack intensity *Spodoptera frugiperda*

Observation of the level of leaf damage is done by looking at the damage caused by pests on maize plants. Observations were made 7 days after planting at 5 day intervals until the corn was 45 days old. Observations of leaf damage were made using the score method based on the percentage of *S. frugiperda* attack area on the leaves. The intensity of attack (IS) was calculated using the formula (Kementan, 2018):

$$I = \frac{\sum (n_i \times v_i)}{N \times Z} \times 100\%$$

I = pest attack intensity

N_i = number of leaves of pest- infested plants

V_i = large scale of attack

N = the highest scale value of the specified attack category

Z = number of plant leaves observed

2.7 Composition of arthropod visits

The calculation of the composition of arthropod visits is carried out by classifying the insects found on the yellow trap, then identifying the insects up to the order level and grouping the obtained insects based on their orders

2.8 Data analysis

Data obtained in the field was tabulated in Excel. Data that has been tabulated and then analyzed using R-Statistics to find the ANOVA value. The result showed significant results which were then followed up with LSD test at 5% significance value.

3. RESULTS AND DISCUSSION

3.1 Percentage of affected plants

From the results of the study, the average percentage of *S. frugiperda* attacks on corn plants continued to increase from plant age 7 (DAP) to plant age 45 (DAP) and began to decline when plants were aged 32 (DAP). The percentage of *S. frugiperda* pests began to increase due to the high population of larvae in plants aged 17-22 (DAP).

Table 1. Percentage of affected plants *S. frugiperda* on 7 DAP- 42 DAP

Treatments	Percentage of affected plants <i>S. frugiperda</i>								Average
	7 DAP	12 DAP	17 DAP	22 DAP	27DAP	32 DAP	37 DAP	42 DAP	
R0	0	12.75 ^a	16.5 ^a	1 ^{cb}	5.5	0.5	0	0	4.5
R1	0	3.25 ^{cb}	7.5 ^{cb}	7 ^a	4.8	0.8	0.25	0	2.9
R2	0	8 ^{ab}	8.5 ^b	10.25 ^a	1.8	1.3	0.75	0	3.8
R3	0	4 ^b	7 ^{dc}	7 ^a	3.3	0.8	0.5	0	2.8
R4	0	8.25 ^a	12.2 ^a	3 ^b	3.0	2.5	0.25	0	3.7
Average	0	7.3	10.4	5.7	3.7	1.1	0.35	0	3.54

Note: Numbers followed by different notations in the same column and observation time show significant differences in the 5% LSD test.

The data obtained from Table 1 is presented in Figure 1. It can be seen that the highest percentage of plants affected by *S. frugiperda* pests with various refugia treatments on corn plants was the control treatment (R0/ corn plants without refugia), and the lowest average percentage of plants attacked was treatment R3 (white refugia plants) *Turnera subulata*.

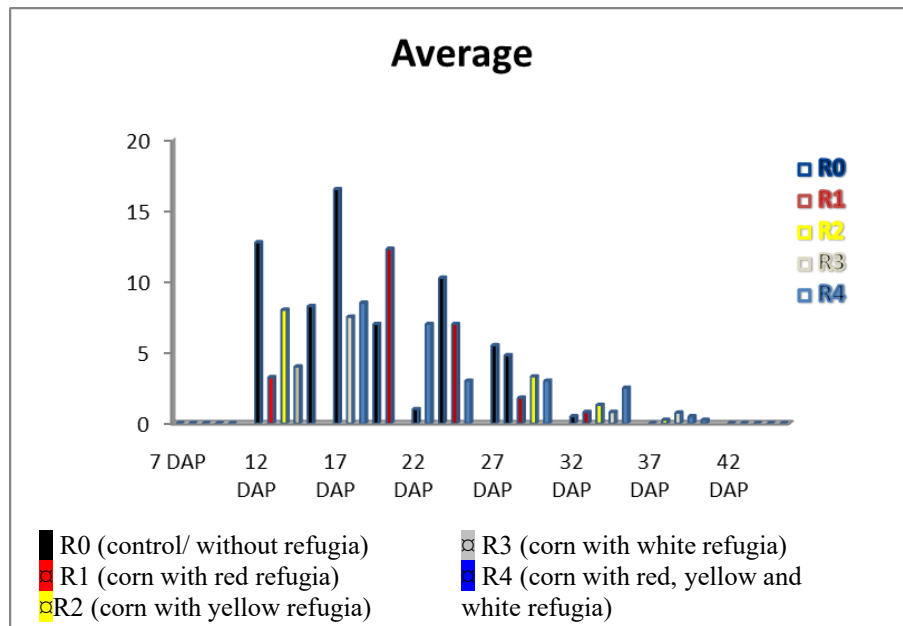


Figure 1. Percentage of affected plants *S. frugiperda* on 7 DAP-42 DAP

The percentage of affected has value fluctuating, where the percentage highest affected of *S. frugiperda* at the time 17 (DAP) with a value of 16.5 on treatment R0(control) with notation (Table 1). Attack *S. frugiperda* the lowest percentage occurred in plants 7 DAP with a value of 0 (Table 1). Factor affecting high pest attack by *S. frugiperda* because these pests like plants young (Meagher et al., 2016). Based on researched (Olsiviana et al., 2024) the importance of choosing the best number and distribution of shelters, as well as the time required to achieve an effective ecological balance in pest control.

In each treatment the highest affected value was in treatment R0 while the lowest was in treatment R3(White refugia) (Figure 1). This is closely related to the existence of the refugia plant itself. Refugia plants indirectly play a role in increasing the presence of natural enemies so that the attack rate in the treatment of flowering plants tends to be smaller than the control treatment. According (Shrestha et al., 2019) that the number of arthropods attracted to refugia plants was higher than land not combined with refugia plants. These refugia become microhabitats for other arthropods. Habitat manipulation in pest control is the addition of non-host flowering plants, which serve as habitats for natural enemies of insect pests (Shrestha et al., 2019).

In the observations conducted at 7 and 42 DAP, there was no percentage of affected in all treatments. In the observation at 7 DAP. The corn plants are still young and the *S. frugiperda* pests are usually still in the phase of laying their eggs. Therefore, there is no percentage of affected. Meanwhile, in the 42 DAP observation, the decrease in *S. frugiperda* pest attacks is also suspected to be due to the influence of trichomes on the corn plant leaves. The continuously growing corn plant leaves cause an increase in the number of trichomes (fine hairs on the leaves), making it difficult for insect mouths to reach the leaf tissue (Siti Herlinda, Yulia Pujiastuti, Chandra Irsan et al., 2021). The denser the leaf trichomes, the less *S. frugiperda* prefers the leaves. Trichomes appear as part of the leaf surface and play a vital role in plants- biotic interactions (Kariyat et al., 2019). (Oksanen, 2018) reported that trichomes have a negative impact on herbivorous insects by preventing or making it difficult for them to consume parts of the plant.

In the observations, it was found that the refuge treatment at 12 DAP, 17 DAP, and 22 DAP had a significant effect and was displayed with notation on the averages. Meanwhile, in the treatments at 7 DAP, 27 DAP, 32 DAP, 37 DAP, and 42 DAP, the flower color did not have a significant effect on the percentage of affected. This finding shows that natural enemies may move around and successfully control insect populations, the ideal density must be determined.

The high percentage of attack in the R0 treatment (control/no refugia) compared to other treatments with refugia indicates that refugia play a role in providing shelter for natural enemies. As a result, the total population of *S. frugiperda* pests tends to be higher in the R0 treatment (control/ no refugia) compared to other refugia treatments. But, the lowest percentage of affected plants on this researched in the R3 treatment (White refugia/ *Turnera subulata*). *Turnera subulata* flowers can increase the effectiveness of refugia plants as the natural control of maize pests (Ardina et al., 2024).

3.2 Attack intensity of *Spodoptera frugiperda* pests in corn fields

The results showed that the treatment of refugia plants did not significantly affect the intensity *S. frugiperda*. The highest intensity (7.005) was in treatment R0 (control) and the lowest (3.84) treatment R3 (white refugia) (Table 2). The intensity of attacks in each week of observation showed that the control treatment R0 was higher than the other treatments, although the results of statistical analysis showed no significant difference between the treatments. So, Table 2 did not show the notations in 5% LSD test.

Table 2. Table of attack percentage of *S. frugiperda* 7 DAP – 42 DAP.

Treatments	Percentage of attack intensity of <i>Spodoptera frugiperda</i>								Average
	7 DAP	12 DAP	17 DAP	22 DAP	27 DAP	32 DAP	37 DAP	42 DAP	
R0	0	23.46	3.3	5.9	14.24	7.18	1.96	0	7.005
R1	0	13.32	5.18	4.8	7.4	7.9	0	0	4.8
R2	0	12.14	10.66	6.6	8	3.2	0.38	0	5.13
R3	0	8.44	11.56	19.9	4.5	1.96	0.4	0	3.84
R4	0	15	6.6	1.96	9.2	3.24	0	0	4.5
Average	0	14.472	7.46	4.815	8.668	4.696	0.548	0	5.09

Note: Numbers followed by different notations in the same column and observation time show significant differences in the 5% LSD test.

The data obtained from Table 1 is presented in Figure 1. It can be seen that the highest percentage of plants attacked intensity by *S. frugiperda* pests with various refugia treatments on corn plants was the control treatment (R0/ without refugia), R2 (yellow refugia) *Melampodium paludosami*, R1 (red refugia) *Zinnia elegans*, and R3 (white refugia) *Turnera subulata*.

Observations is showed that the intensity of pest attacks by *S. frugiperda* was low (Table 1) (Figure 2). This is very closely related to the existence of refugia. According (Sitepu et al., 2018) that vegetation diversity increases diversity of potential natural enemy species suppress the population of plant disturbing organisms. The addition of refugia on cultivated land can be disturbed by insect pests in search of its host. According (Sarjan et al., 2023), stating that by giving addition of flowering plants planted on the edge of the chili planting field in the treatment refugia can affect pests. It is suspected that the initial intensity of the attack and the continued decline in the number of populations was due to the collection of pest eggs and larvae in this study. *S. frugiperda* so that the pest population decreases and the attack rate also decreases.

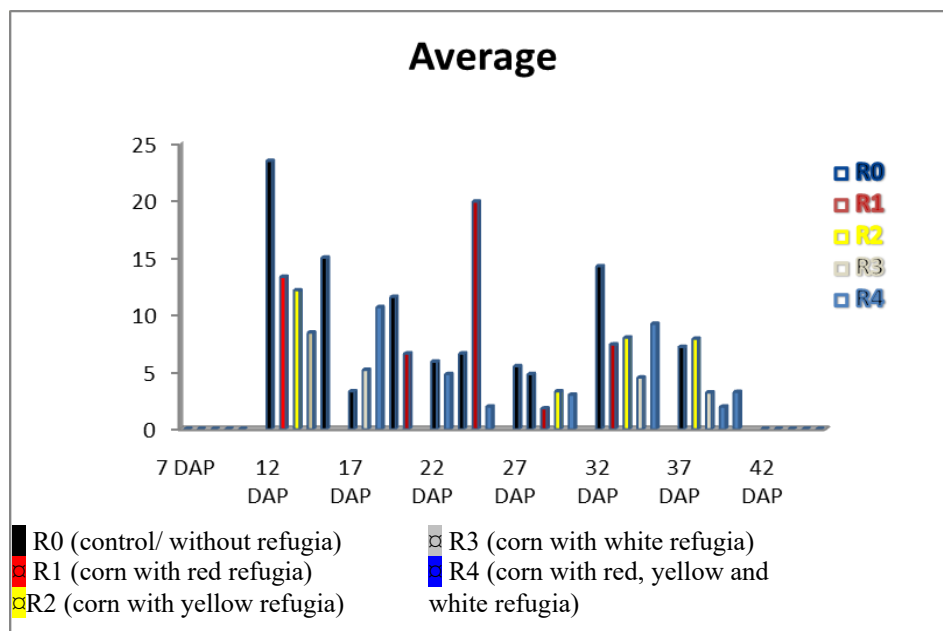


Figure 2. Percentage of Attack Intensity of *S. frugiperda* on 7 DAP-42 DAP

Based on Table 2, it is known that the intensity of *S. frugiperda* pest attacks varies with each observation. This is suspected to be due to the differences in each instar of *S. frugiperda* larvae, which have different feeding requirements for each instar. This is supported by the literature (Nonci et al., 2019), *S. frugiperda* damages corn plants by having its larvae mine the leaves. The larvae exhibit cannibalistic behavior.

The highest pest attacks can be observed in the early weeks of the study, but by the end of the study, pest attacks tend to decrease in line with the weekly reduction in population. According

to (Rondonuwu, 2007), the intensity of damage to plants typically follows the population of pests that cause the damage, indicating that the pest population has a significant impact on plant damage. The extend of damage to the plants is influenced by the pests that damage those plants.

3.3 Composition of arthropod visits

The composition data of arthropod visits to corn plants show that the highest percentage comes from the order Hymenoptera, followed by the orders Diptera, Coleoptera, Hemiptera, Orthoptera, Lepidoptera, and Araneae (figure 3).

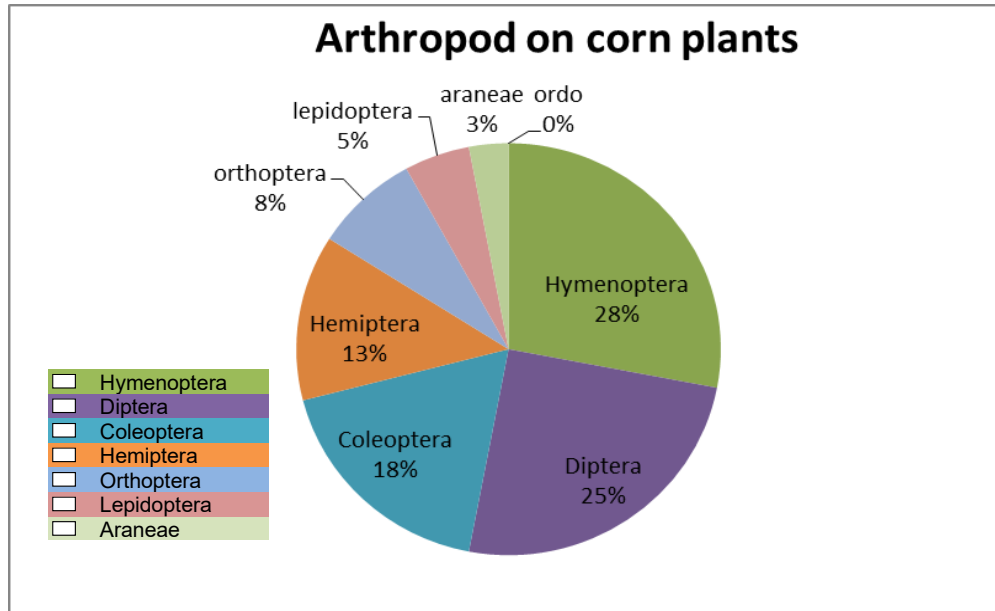


Figure 3. the composition of arthropod visits on corn with refugia

Table 3 below shows the types of arthropods captured in yellow traps around corn fields. Several orders and families of arthropods were identified, and their roles in nature were examined. Some are predators, parasitoids, detritivores, or herbivores.

Table 3. Visit of arthropods on corn plants with refugia

No	Ordo	Family	Status
1	Hymenoptera	Formicidae	Predators
		Scelionidae	Parasitoids
2	Diptera	Aphelinidae	Parasitoids
		Muscidae	Detritivore
3	Coleoptera	Lauxaniidae	Detritivore
		Coccinellidae	Predatore
4	Hemiptera	staphylinidae	Predators
		Aleyrodidae	Herbivore
5	Orthoptera	Miridae	Herbivore
		Acrididae	Herbivore
6	Lepidoptera	Noctuidae	Herbivore
7	Araneae	Araneadae	Predators

The stability of the ecology will impact the visitation of arthropods. In the research observation conducted, 7 orders of insects were found. In figure 1, the percentage of insects was in the order Araneae. The presence of arthropods in corn cultivation areas planted with refugia is influenced by biotic and abiotic factors (Muhammad Richsan Yamin, Siti Annisaa'ul Kariimah, Nadya Rizky, Nuzul Ramadhanti, 2011). The influence of the abundance or scarcity of arriving arthropods is in the form of abiotic factors such as light intensity. Other abiotic factors such as temperature and humidity, where insects have a specific temperature range in which they can live. Based on research (Astutik & Kurniahu, 2022) that the visitation behavior of arthropods in refugia blocks is influenced by competition among arthropod species in obtaining food. (Azizah et al., 2022) reported that refugia support changes in arthropod composition, which impacts parasitoids that can suppress herbivore populations.

The Hymenoptera order was most frequently captured using yellow traps placed around corn fields with refugia. The abundance of the Hymenoptera order around corn fields with refugia indicates that the incidence of parasitism in nature is quite high. If there are no natural enemy species dominating the population, the likelihood of significant population fluctuations that could disrupt the ecosystem balance can be reduced. These findings align with the idea that biodiversity

and balanced contributions from ecosystems will be supported by a balanced ecosystem (Kumar et al., 2021).

Hymenoptera found in the corn cultivation area with refugia act as predators and parasitoids. Predator Hymenoptera include the family of Formidae, while the parasitoid families include Scelionidae, Trichogrammatidae, Eulophidae, etc. Based on researched (Ardina et al., 2024), it was found that the egg parasitoids obtained from the corn cultivation area with refugia treatment belong to the Scelionidae family.

The presence of other orders found in this study, such as the orders Diptera, Coleoptera, Hemiptera, Lepidoptera, or Araneae indicated that the abundance of arthropods around corn fields with refugia was high. The presence of alternative hosts, refugia plants, and shelter improves parasitoid life span (Hilker & Fatouros, 2015). The diversity of arthropods around corn crops with refugia causes the environmental conditions of the crops to become balanced between natural enemies and pest populations.

4 CONCLUSION

The resultsof that study indicate that the treatment of refugia plants did not significantly affect the intensity *S. frugiperda*. In each treatment the highest attack value was in treatment R0 while the lowest was in treatment R3(White refugia) *Turnera subulata*. However, the treatment of refuge plants on the percentage of attack had a significant effect observations at 12, 17, and 22 DAP. Meanwhile The percentage of attack intensity of *Spodoptera frugiperda* showed that the best treatment was R3 (maize with white refugia) *Turnera subulata* where the presence and intensity of attacks can be suppressed by the presence of refuge plants. However, in a study observing the composition of arthropod visits to corn plants with refuge plant treatments, it was found that insects from the order Hymenoptera were the most abundant around corn plants with refuges. The presence of this order clearly impacts the population of the pest *S. frugiperda* because most Hymenoptera are natural enemies. In the end of researched we conclude that the area plates with refugia provides a diversity enemies, resulting in minimal plant damage, which in turn enhances productivity and good growth for the corn plants themselves.

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