JoSSEd
Journal of Science and Science Education
ISSN: 2774-1869 eISSN: 2774-2105
Research Paper

The Existence of Predatory Insects in the Agroecosystem of Potato Plants (Solanum tuberosum L.) Integrated with Refugia Plants

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DOI: 10.29303/jossed.v4i2.5901

Article Info
Received: July 15, 2023
Revised: August 22, 2023
Accepted: September 30, 2023
Published: October 31, 2023

Abstract: Inappropriate handling of pests can cause substantial losses in both quantity and quality of potato plants. One of the promising alternative methods is by modifying the agroecosystem such as using refugia plants to conserve the diversity of predators in potato plants. This study aimed to determine the effect of refugia plants on the diversity of predatory insects in potato plants. This study used a randomized block design (RBD) with 6 treatments and 3 replications. Sampling of predatory insects was carried out using traps, namely the yellow pan trap and direct (conventional) collection. The results of this study indicated that there were 3 orders of predatory insects from 3 families and 9 species. The most common insects were found in the treatment of marigold and sunflower flowers. The highest diversity index value was 1.33 obtained in the sunflower treatment, which is classified as moderate.

Keywords: Potatoes; Refugia; Predator

Citation: Sarjan, M., Thei, R.S.P.., Fauzi, M.T., Kisman, K., & Haviana, A. (2023). The Existence of Predatory Insects in the Agroecosystem of Potato Plant (Solanum tuberosum L.) Integrated with Refugia Plants. *Journal of Science and Science Education*, *4*(2), 107–114. https://doi.org/10.29303/jossed.v4i2.5901

INTRODUCTION

Potatoes (Solanum tuberosum L) are one of the important commodities in Indonesia which have the potential to support food diversification programs. This is important because it is to overcome people's dependence on food needs which only depend on rice. In NTB Province, production and the area planted with potatoes from 2017 to 2021 experienced fluctuations. The decline in potato production occurred due to inefficient use of production factors, climate, land degradation due to excessive use of pesticides, low quality of seeds used, soil fertility and pests and plant diseases (Baihaqi et al, 2013).

The impacts caused by pests encourage farmers to take control measures, one of which is using chemical pesticides (Pribadi et al., 2020). The use of pesticides is actually the last alternative and its use is rational and wise. However, the reality in the field is that farmers use pesticides on a large scale (Septariani et al., 2019), this will cause damage to the balance of the ecosystem, resulting in the pest population increasing but the population of natural enemies capable of controlling the pest population decreasing. The existence of these negative impacts requires environmentally friendly, effective and efficient control, namely by using Integrated Pest Management (IPM) control techniques, namely using vegetable insecticides, apart from that, you can also use natural enemies, one of which is predators (Aspect et al., 2019).

Predators are animals or insects that prey on other animals or insects to fulfill their living needs and these animals are included in level 2 or level 3 in the tropic level of the food chain, namely animals that are classified as meat eaters (carnivores) and omnivores (omnivores) (Sarjan, 2012). To maintain the presence of natural enemies, conservation needs to be carried out, namely by using a more diverse plant

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system, suppressing excessive use of pesticides, planting and preserving flowering plants or what is often called refugia (Nurariaty, 2014). Refugia are microhabitats that provide spatial or temporal shelter for natural enemies of pests, such as predators and parasitoids, and support biotic interaction components in the ecosystem, such as pollinators or pollinating insects (Keppel et al., 2012). There are different species of predatory insects in a potato growing area, so the diversity obtained will vary. Therefore, research was conducted on the diversity of predatory insects on potato plants in Sembalun Village, with the aim of determining the diversity, abundance and dominance of predatory insects on potato plants in Sembalun Village.

METHOD

Time and place of research

This research was carried out at coordinates 8o22'54.5" and 116o32'38" East Longitude, Sembalun Village, Sembalun District, East Lombok Regency, West Nusa Tenggara, using experimental methods in the field. The potato seeds used are granola varieties, marigold refugia plants, sunflowers, paper flowers, kenikir flowers, and snow peas.

Experimental design

The design used in this research was a Randomized Block Design (RAK) with 6 treatments and each treatment was repeated 3 times to obtain 18 experimental units. The treatments used were as follows: P0: Control, P1: Treatment of kenikir flowers, P2: Treatment of pea plants, P3: Treatment of sunflowers, P4: Treatment of marigold flowers, and P5: Treatment of zinnia flowers. To collect the observed sample plants, 6 plants/plots were taken for potato plants and 3 plants/plots for refugia plants, so that 162 sample plants were obtained.

Implementation of research

The land used in this research is a farmer's potato cultivation land with an area of around 2 acres (216 m2) with a land length of 18 m and a width of 12.3 m. To make plotting easier, 18 experimental plots were created with an area of 4.1 x 3 m per plot. The land used is processed first to loosen the soil, and left for two weeks before making beds and covering them with plastic mulch. Before planting, the refugia plants are first seeded so that when the potatoes start to grow the refugia plants will already be flowering. The potato variety used is the granola variety. Planting potatoes and refugia is carried out on the same day, then observations are carried out every week.

Population of insect pest predators on potato plants

To obtain predator population data, the number of predators obtained was calculated. The predator population is calculated using a hand counter directly in the field. Insect predator diversity index. The diversity of predator types was determined from the results of specimen collections obtained during the research, then the diversity index value was calculated using the Shannon-Weiner diversity formula (Michael, 1998).

$$H' = -\sum_{i=1}^{n} pi \ln pi \quad (1)$$

$$pi = \frac{ni}{N} \quad (2)$$

Information :
H'= Shannon-Wiener diversity index
pi = proportion of the number of 1st individuals to the total number of individuals
ni = 1st species
N = total number of individuals

The range of values for calculating the diversity index is H < 1, then the diversity is low, then if H = 1 < H < 3, then the diversity is medium and if H > 3 then the diversity is high.

Insect predator abundance index

The abundance index is calculated after knowing the high and low predator populations per unit time, calculated using the formula Michael (1995):

$$\text{Abundance (K)} = \frac{\sum \text{numberof individuals of species i}}{\text{The number of individuals of the entire species}} x100 \qquad (3)$$

Insect predator dominance index

To determine the dominance of certain predators in potato plantings, it can be calculated using the Simpson'a dominance index (Odum, 1997).

$$C = \sum_{i=1}^{n} \left[\frac{n_i}{N} \right]^2 \qquad (4)$$

Information :
C = Simpson dominance index
ni = number of individuals of type i
N = total number of individuals

Insect predator evenness index

The evenness index is used to see the evenness of insect species in an ecosystem as a whole (Magurran, 2004) as follows:

$$E = \frac{H'}{Hmax} \qquad (5)$$

Information:
E = Evenness index (0-1)
H' = Shanon-Wiener species diversity index
Hmax = Maximum diversity index = ln S, where S: number of types (species)

Potato Crop Results

Harvesting of potato tubers is carried out at 90 HST of the potato plant. Then 3 samples of potato plants were taken from each experimental plot, then the weight of the tubers and the number of tubers planted were calculated.

Identify pest insect predators

Insect identification is carried out using a binocular microscope and a 1000x USB microscope by referring to books, journals and other literature to determine the species. Identification of predatory insects is done by observing the morphological characteristics of adult insects. Identify specimens using morphological characteristics of the wings and the color and pattern on the backs of adult insects.

Data analysis

Observational data were analyzed using diversity analysis at a 5% real level and analysis results that were significantly different were tested using honest significant differences (BNJ) at a 5% level. However, if the resulting data analysis is not significant then no further tests are carried out

RESULT AND DISCUSSION

From the identification results, it was found that there are 3 orders, namely orthoptera, hymenoptera and coleoptera, then there are 3 families and 9 species of predatory insects on potato plants, namely from the families Formicidae, Coccinellidae and Mantidae. The 9 species of predators are: a. Dolichoderus bituberculatus, b. Mantis religiosa, c. Coccinella transversalis, d. Cryptoleamus montrouzieri, e. Coleophora inaequalis, f. Cheilomenes sexmaculata, g. Axion plagiatum, h.Coleophora reniplagiata, and Illeis koebelei, which were observed directly in the potato planting area.

Predatory Insect Populations

Based on the results of observations, it shows that the predatory insects most commonly found are the Order Hemynoptera on potato plants and the Order Coleoptera on refugia plants. In the Hemynoptera order, the species obtained were Dolichoderus bituberculatus, totaling 87 individuals, while in the refugia plant there were 7 species obtained, namely*Coccinella transversalis, Cryptoleamus montrouzieri, Coleophora inaequalis, Cheilomenes sexmaculata, Axion plagiatum, Coleophora reniplagiata*, and Illeis

koebelei, with a total of 386 individuals. Meanwhile, in this study, the few predatory insects of the Orthoptera order were found with a total of 33 individuals. The species found was Mantis religiosa.

Table 1. Number of Individual Predator Insects Obtained on Potato Plants and Refugia Plants

Plant	Order	Family	Species	Treatment						Total
				P0	P1	P2	P3	P4	P5	
Potato	*Orthoptera*	*Mantidae*	*mantis religiosa*	3	4	1	3	3	2	16
	Hymenoptera	*Formicidae*	*dolichoderus bituberculatus*	9	11	7	9	41	10	87
	Coleoptera	*Coccinellidae*	*coccinella transversalis*	1	2	5	1	1	3	13
			cryptoleamus montrouzeri	-	-	1	2	-	-	3
			Coleophora inaequalis	2	2	3	3	2	1	13
			cheilomenes sexmaculatus	8	3	8	15	5	-	39
			axion plagiatum	-	-	-	-	-	-	0
			Coleophora reniplagiata	-	-	6	11	2	-	19
			illeis koebelei	-	-	-	2	1	-	3
	Total			23	22	31	46	55	16	
Refugia	*Orthoptera*	*Mantidae*	*mantis religiosa*	3	-	-	12	1	1	17
	Hymenoptera	*Formicidae*	*dolichoderus bituberculatus*	-	-	4	8	2	-	14
	Coleoptera	*Coccinellidae*	*coccinella transversalis*	3	9	1	19	1	7	40
			cryptoleamus montrouzeri	-	-	-	18	-	2	20
			Coleophora inaequalis	5	2	2	29	1	2	41
			cheilomenes sexmaculatus	12	9	3	64	36	20	144
			axion plagiatum	-	1	-	5	-	-	6
			Coleophora reniplagiata	3	3	-	21	-	3	30
			illeis koebelei	-	2	4	91	1	7	105
	Total			26	26	14	267	42	42	

If you look at table 1, the difference in the number of predators obtained on potato plants and refugia plants is very different, this is thought to be because refugia plants have their own charm, such as striking flower colors, a distinctive smell, various flower sizes, as is the case according to Wardana et al. , (2017) flowering plants attract insects using the morphological and physiological characteristics of flowers, namely size, shape, color, fragrance, flowering period and nectar and pollen content.

The high population of the species Dolichoderus bituberculatus is due to the ability of one ant queen to reproduce eggs, which can reach 5000 eggs per head in one day and has the habit of living in groups. This is confirmed by (Sardhi et al., 2021)which states that the Formacidae family is the most common insect and its tribe has the largest number of activities on the ground. Meanwhile, in the order Coleoptera, the most commonly found species is Cheilomenes sexmaculata. This is thought to be because the C. sexmaculatus species has a wide prey range compared to other species. Aphis, whiteflies, and mealybugs are the main prey of C. sexmaculatus. Apart from that, C.sexmaculatus has a unique way of preying where this predator preys both day and night (Hidayat et al., 2021). The highest presence of C. sexmaculatus in cultivated land is also due to its ability to survive with limited prey as well as high reproduction and a long life cycle.

Diversity (H'), Abundance (K), Dominance (D) and Evenness (E) of Predatory Insects

The highest diversity index was in the sunflower treatment, namely with a value of 1.33. The high diversity index value in sunflowers is thought to be because sunflower plants have striking flower colors and quite large flower sizes.Rosadi & Rahmat, (2022)said sunflowers have yellow flowers with quite large flower

sizes and a large number of petals. This value indicates that the diversity index value of predatory insects on potato plants is classified as moderate because the diversity index value (H') = 1 or 1<H'>3. A moderate diversity index value indicates that predatory insects on potato plants are quite diverse. According to Nurudin et al., (2013), that the high and low diversity index (H') is greatly influenced by the number of families and population size. If there are more species but only in one family then diversity is low, compared to if there are fewer species but in several families then diversity is high. Apart from that, low diversity values are also influenced by weather factors that are less favorable for the development of insect life in a habitat.

Table 2. Diversity (H'), Abundance (K), Dominance (D) and Evenness (E) of Predatory Insects in Several Refugia Plant Treatments.

Treatment	Diversity (H')	Abundance (K)	Dominance (D)	Evenness (E)
P0	0.97a	13.53a	0.41a	0.47 a
P1	0.61 a	11.77a	0.40 a	0.29 a
P2	1.15a	16.57a	0.30a	0.55 a
P3	1.33a	22.82a	0.31a	0.63 a
P4	0.77a	26.13a	0.58a	0.37 a
P5	0.63 a	8.46a	0.37 a	0.29 a
BNJ%				

The abundance index values for insect predators that were most commonly found were in marigold flowers and sunflowers. The presence of predatory insects on marigold and sunflower flowers is due to their striking flower colors and nectar content. Predatory insects are attracted to refugia plants because they have bright flower colors in response to seeing insects on the plants (Adawiyah et al., 2020). Predatory insects have a type of vision that can absorb bright yellow, green and pink (Sihombing et al., 2013).

The highest dominance index value was mostly found in the zinia flower treatment with a value of 0.58. The high value of the predator dominance index on zinnia flowers is thought to be because the predator diversity index value in this treatment has a low value. According to Tustiyani et al., (2020), if the diversity index value is high then the dominance index value is low, and vice versa, if viewed based on the dominance index criteria, the dominance index value of predatory insects on potato plants is low, which means there is no dominant species.

The highest evenness index value was most often found in the sunflower treatment with a value of 0.63. The evenness index value of predator species in potato plants is classified as moderate. According to Rizal*et al*., (2002) that the population of each organism in an ecosystem is never the same at any time, but there are ups and downs. Likewise, ecosystems that are formed from their physical environment always experience change and growth from time to time.

Potato crop yield

The results of analysis of variance (ANOVA) showed that the number of tubers in treatment P0 was not significantly different from all treatments as well as the weight of potato plant tubers. The P0 (control) treatment had the highest average number of tubers, namely 13.4 with a tuber weight of 0.52 grams, and the sunflower treatment had the highest average tuber weight with an average number of tubers, namely 10.67. This is thought to be because the level of damage caused by whitefly pests is still relatively light, namely around 5%, so the results are still quite good.

Table 3. Number of tubers and tuber weight of potato plants

Treatment	Number of Bulbs	Tuber Weight	IS(%)
P0	13.44 a	0.58 a	2
P1	10.44 a	0.58 a	5.33
P2	10.78 a	0.58 a	2
P3	10.67 a	0.68 a	2.33
P4	11.11 a	0.62 a	2
P5	10.33 a	0.65 a	1.66
BNJ 5%			

Note: Numbers followed by the same letter in the same column are not significantly different in the 5% BNJ test

The higher the level of damage caused by pests, the lower the crop yield will be. The whitefly pest is the prey of predators, the higher the predator population, the greater the ability to control the pest. Sahara et al., (2022)states that natural enemies as regulators and controllers of pest insect populations, can increase their prey activities and populations, if the population of the pest insects that are their prey increases. Biological control is safe for the environment because it does not harm other living creatures that are not targets so it does not cause pest resurgence or pest explosions. If natural enemies of predators can act as predators optimally, then the populations of pests and natural enemies will be balanced, so that pest explosions will not occur and can reduce insect populations significantly (Sahara et al., 2022). The treatment using refugia here is aimed at attracting insects, because refugia plants can provide shelter and a food source for insects.

CONCLUSION

Based on the results of the discussion, it can be concluded that 9 types of predatory insects were obtained, namely Dolichoderus bituberculatus, Mantis religiosa, Coccinella transversalis, Cryptoleamus montrouzieri, Coleophora inaequalis, Cheilomenes sexmaculata, Axion plagiatum, Coleophora reniplagiata, and Illeis koebelei. The diversity index value of predatory insects in general in potato planting areas in the Sembalun area is classified as moderate, as is their abundance, the dominance index of predatory insects in potato plants is low, which means no species dominates, and the evenness index value is medium, which means the community is evenly distributed. The species Cheilomenes sexmaculatus, illeis koebelei and Dolichoderus bituberculatus have the highest populations compared to the other 6 species.

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