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Diversity and Relative Abundance of Insect Pests in Cayenne Pepper Cultivation under Monoculture and Intercropping Systems

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ABSTRACT

Information on the effect of combining intercropping systems, refugia, and repellent plants on the insect pest community structure in cayenne pepper cultivation remains limited. This study aimed to analyze the diversity and relative abundance of insect pests in cayenne pepper under monoculture and intercropping systems combined with refugia and repellent plants. The study was conducted from March–September 2025 in Kilang Village, East Lombok using a Randomized Block Design with six treatments and four replications. Insect sampling was carried out using Yellow Pan Traps, Pitfall Traps, and Brocap pheromone traps over 12 observation periods. Results showed that 758 individual insect pests were found belonging to 7 orders, 16 families, and 22 species. The pest community was dominated by *Bactrocera* spp., *Liriomyza* sp., and *Thrips* sp. The cayenne pepper monoculture treatment produced the highest number of pest individuals (220 individuals), while the cayenne pepper + tomato + lemongrass intercropping treatment produced the lowest (91 individuals). Meanwhile, the cayenne pepper + tomato + marigold treatment yielded the highest diversity index (H' = 2.06) and the lowest dominance (D = 0.16), indicating the most stable insect community. The results indicate that the combination of intercropping, refugia, and repellent plants not only suppresses pest abundance but also enhances insect community stability in the cayenne pepper agroecosystem.

INTRODUCTION

Indonesia is a tropical country where various food and horticultural crops can be cultivated. Cayenne pepper (*Capsicum frutescens* L.) and tomato (*Solanum lycopersicum* L.) are two horticultural crops from the Solanaceae family with high economic value and numerous benefits for human life. Cayenne pepper and tomato contain vitamins, minerals, and carbohydrates with high nutritional content, and are widely used as ingredients in various food products to enhance flavor and as traditional medicinal materials (Tsurayya & Kartika, 2015; Sembel, 2018).

Cayenne pepper production in Indonesia fluctuates annually. In 2021, production reached its highest value of 134.4 thousand tons and its lowest of 94.54 thousand tons (BPS, 2024). West Nusa Tenggara Province (NTB), as one of the centers of cayenne pepper production in Indonesia, experienced production fluctuations over the past five years. From 2020 to 2022, production declined consecutively to 989.414 quintals (q), 625.389 q, and 500.784 q, while in 2023 and 2024 it increased significantly to 679.631 q and 941.552 q, respectively (BPS, 2024). These fluctuations can be caused by many factors, with one of the most important being attacks by plant-disturbing organisms in the form of insect pests that damage crops. Several previous studies have identified various major pest species attacking cayenne pepper, including thrips (*Thrips palmi*, *T. tabaci*, *Scirtothrips dorsalis*), aphids (*Aphis gossypii*, *A. glycine*, *Myzus persicae*), whitefly (*Bemisia tabaci*), fruit flies (*Bactrocera dorsalis*, *B. umrosa*, *B. carambolae*, *Drosophila melanogaster*), mealybugs

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(*Pseudococcus* sp., *Planococcus* sp.), stink bugs (*Nezara viridula* L.), grasshoppers (*Locusta* sp.), armyworm (*Spodoptera litura*), and mites (*Polyphagotarsonemus latus*) (McDougall et al., 2013; Sembel, 2018; Januarisya et al., 2023; Mursyidin et al., 2024).

Most farmers generally control pests using synthetic insecticides as they are considered faster and more effective in suppressing pest populations. However, excessive and continuous use will cause various negative impacts. Exposure to these chemicals not only kills pests directly but can also kill non-target organisms such as natural enemies (predators and parasitoids), which can disrupt agroecosystem balance (Jayasiri et al., 2022), and disrupts human health and the environment (Shaki et al., 2020). Therefore, it is necessary to apply safer and more environmentally friendly pest control methods, one of which is ecological engineering through intercropping main crops with companion plants such as refugia and repellent plants to support sustainable pest management.

Agroecosystem management through intercropping systems can support the role of various biological components in the ecosystem, including enhancing the effectiveness of natural enemies in controlling pests. Furthermore, intercropping systems can increase crop yield because various plant species are cultivated, making land productivity more efficient (Kolvanagh & Hokati, 2012; Warman & Kristiana, 2018). The application of intercropping systems has been widely practiced as an effort to reduce pest attacks, in line with achieving a balance between ecosystem sustainability and farmer income. Cayenne pepper and tomato intercropping as an implementation of ecological engineering can provide different microhabitat conditions for natural enemies that naturally suppress pest populations, thereby reducing crop damage compared to monoculture systems (Heviyanti & Mulyani, 2016; Moekasan, 2018).

The use of refugia as companion plants around main crops can attract and support the preservation of natural enemies as alternative host-seeking, breeding, shelter, and foraging sites, thus supporting natural enemy conservation efforts in suppressing pest populations (Kumar & Shakunthala, 2016; Aparicio et al., 2021). In addition, the planting of repellent plants can also be an alternative strategy considered effective in suppressing agricultural pest populations, as the active compounds of repellent plants can hinder pest's ability to locate their host plants (Deletre et al., 2016). Various refugia plants such as marigold (*Tagetes* spp.) and zinnia (*Zinnia elegans*) can provide nectar and pollen beneficial for parasitoids and predators, thereby enhancing their effectiveness in the agroecosystem (Azizah et al., 2022). Furthermore, some plants with repellent properties such as lemongrass (*Cymbopogon nardus*) and basil (*Ocimum basilicum*) can produce essential oils known to repel pests through various mechanisms such as olfaction, vision, texture, and characteristic flavors disliked by pests (Damayanti & Pebriyeni, 2015).

The combination of refugia and repellent plants in the cayenne pepper-tomato intercropping system represents a complementary and synergistic ecological approach. Refugia plants serve as habitat for natural enemies such as predators and parasitoids, while repellent plants actively repel insect pests through their volatile compounds. Combining these two strategies simultaneously is expected to create a more stable agroecosystem condition, where top-down pressure through natural enemies and bottom-up pressure through pest repellency work simultaneously to effectively suppress pest populations (Gurr et al., 2017; Acimovic et al., 2025).

Studies on the application of refugia and repellent plants separately in chili cultivation have been widely conducted, but research on their combined effects within a cayenne pepper–tomato intercropping systems remain limited. Jasmi et al. (2023) reported that refugia plants significantly affected the whitefly population and the percentage of pest attack in red chili plants. Thei (2021) reported that the use of repellent plants such as basil, effectively suppressed *Thrips* spp. populations through the emission of essential oils and flavonoid compounds that interfere with host–location behavior. In addition, Gunaeni et al. (2022) reported that intercropping chili pepper with tomato reduced aphid, whitefly, and thrips population compared with chili monoculture. These findings indicate that crop diversification has considerable potential to suppress insect pests through multiple ecological mechanisms. Furthermore, Jaworski et al. (2023) demonstrated that intercropping systems generally increase beneficial insect abundance while reducing pest populations by enhancing habitat complexity and ecological interactions.

However, previous studies have primarily focused on the effects of intercropping with a single companion crop, while the combined use of intercropping, refugia, and repellent plants as an integrated ecological engineering strategy has received limited attention. Therefore, this study aimed to evaluate the effects of monoculture and intercropping systems integrated with refugia and repellent plants on the diversity and relative abundance of insect pests in cayenne pepper cultivation. We hypothesized that increasing plant diversity through ecological engineering would reduce insect pest abundance while promoting a more balanced insect community.

MATERIALS AND METHODS

1. Time and Location

This research was conducted from March–September 2025 in Kilang Village, Montong Gading District, East Lombok Regency, West Nusa Tenggara, at coordinates 8º31'36''S 116º32'55″E and an altitude of 450 m asl. Insect pest identification was carried out at the Plant Protection Laboratory, Faculty of Agriculture, University of Mataram.

2. Research Design

This study used a Randomized Block Design (RBD) consisting of six treatments and four replications, resulting in a total of 24 experimental units. The treatments tested were T1: cayenne pepper monoculture (control); T2: cayenne pepper + tomato; T3: cayenne pepper + tomato + marigold (*Tagetes* sp.); T4: cayenne pepper + tomato + zinnia (*Zinnia elegans*); T5: cayenne pepper + tomato + basil (*Ocimum basilicum*); and T6: cayenne pepper + tomato + lemongrass (*Cymbopogon nardus*).

This study was conducted in an experimental field measuring 13.4 m × 18.9 m, which was divided into 24 experimental plots separated by 0.5 m buffer zone. Each plot measured 3 m × 1 m, with a bed height of approximately 30 cm and an inter-bed spacing of 50 cm. The experimental area was divided by an irrigation canal (embankment) separating the western and eastern plot blocks (Figure 1).

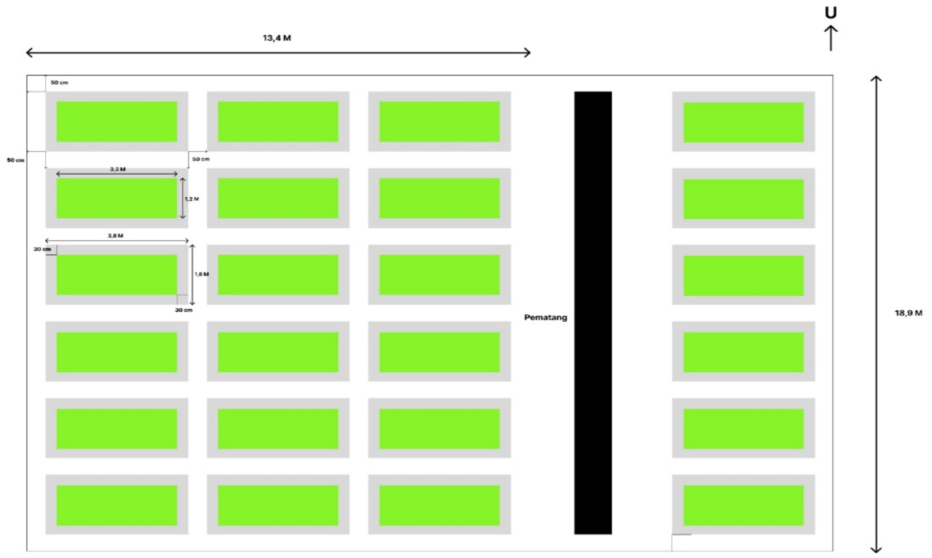

Figure 1. The experimental field layout within each treatment plot

Each experimental plot contained 12 cayenne pepper plants arranged at a spacing of 50 cm × 50 cm. In the intercropping treatments, six tomato plants were established in the center of each plot at alternating positions between cayenne pepper plants, resulting in a 2:1 ratio of cayenne pepper to tomato plants, and 16 companion plants, consisting of refugia or repellent species, were established around the perimeter of the experimental plots at 50 cm spacing. A total of 288 cayenne pepper plants, 144 tomato plants, and 64 individuals of each companion plant species were used throughout the experiment.

3. Research Implementation

The research land was cleared of weeds and plant residues, then tilled until loose. Experimental plots were established according to the research design with predetermined plot sizes and spacings. Cayenne pepper and tomato seedlings that had reached transplanting age were transplanted into each treatment plot. In refugia treatments (marigold and zinnia) and repellent treatments (basil and lemongrass), plants were grown surrounding the experimental plots. Plant maintenance included gap filling, watering, weeding, fertilization, and staking according to standard cayenne pepper and tomato cultivation techniques commonly applied by farmers. During the study, no synthetic insecticides were applied to maintain the natural condition of insect communities in each treatment.

Insect sampling was carried out using three types of traps: Yellow Pan Traps (YPT), Pitfall Traps (PT), and pheromone traps. One trap unit was installed in each experimental plot. YPT was placed at a height equal to the plant canopy to capture flying insects attracted to yellow color, while PT was set flush with the soil surface to capture insects active on the ground surface. Brocap pheromone traps were installed to attract specific target insects, particularly fruit flies (*Bactrocera* spp.). All traps were installed at 08:00 a.m. Central Indonesia Time (WITA; UTC+8) and left in the field for 24 hours before insect collection. Observations were conducted 12 times during the research period from the vegetative to generative growth stages of the plants at one-week intervals. Trapped insects were collected, counted, and preserved in 5 mL Eppendorf tubes containing 70% alcohol for laboratory identification.

4. Insect Pest Identification

Insect pest specimens were identified based on morphological characters such as body color, antenna type, wing venation, and other characteristics using a Euromex EduBlue microscope and documented with a digital camera. Identification was carried out to family/genus level and to species level when possible. Identification references used included Goulet and Huber (1993), Kalshoven (1981), relevant journals, and websites such as BugGuide.Net and iNaturalist.

5. Data Analysis

Data obtained were analyzed descriptively and quantitatively using the Shannon-Wiener diversity index (Magurran, 1998), Evenness index (Odum, 1998), Simpson Dominance index (Odum, 1998), and the relative abundance index of each species (Molina-Ochoa et al., 2001).

Species diversity index was measured using the Shannon-Wiener diversity index (Magurran, 1998) as follows:

$$H' = -\sum p_i \ln p_i$$
$$pi = \frac{n_i}{N}$$

H’: Shannon-Wiener diversity index; pi: number of individuals of a species; ni: number of individuals for the observed species; N: total individuals, with categories high: H’ ≥ 3; medium: 1 < H’ ≤ 3; and low: 0 < H’ ≤ 1.

Evenness index was measured using the evenness index (Odum, 1998) as follows:

$$E = \frac{H'}{\ln s}$$

E: evenness index; H’: Shannon-Wiener diversity index value; S: total number of species, with categories high: E > 1; medium: 0.31 < E < 1; and low: E < 0.31.

Species dominance index was measured using the Simpson dominance index (Odum, 1998) as follows:

$$D = \sum \left[\frac{n_i}{N}\right]^2$$

D: species dominance index; ni: number of individuals for the observed species; N: total of individuals, with categories high: 0,75–1; medium: 0.5–0.75; and low: 0–0,5.

The relative abundance of each species found was calculated using the formula by Molina-Ochoa et al. (2001) as follows:

$$RA = \frac{Ni}{Nt} \times 100\%$$

RA: relative abundance; Ni: number of individuals of species i; Nt: total number of individuals collected.

RESULTS AND DISCUSSION

1. Diversity and Abundance of Insect Pest

The results showed that a total of 758 insect pest individuals belonging to 7 orders, 16 families, and 22 species were recorded in cayenne pepper fields (Table 1). The insect pest community consisted of species from the orders Orthoptera, Coleoptera, Diptera, Hemiptera, Thysanoptera, and Lepidoptera. The diversity of insect pest species varied considerably among treatments. The highest number of pest species was recorded in T6 (cayenne pepper + tomato + lemongrass intercropping), with 15 species, followed by T3 (cayenne pepper + tomato + marigold intercropping), with 14 species. Meanwhile, T1 (cayenne pepper monoculture) and T5 (cayenne pepper + tomato + basil intercropping) each harbored 13 species. The lowest number of pest species was observed in T2 (cayenne pepper + tomato intercropping) and T4 (cayenne pepper + tomato + zinnia intercropping), each with 11 species. The highest pest abundance was recorded in T1, with 220 individuals, whereas the lowest abundance was observed in T6, with only 91 individuals.

Differences in the number of pest species and individuals in intercropping systems indicate that increased plant vegetation in the treatment plots can reduce pest populations compared to monoculture treatment plots, which have simpler plant heterogeneity (Januarisya et al., 2023). Monoculture systems tend to have higher habitat homogeneity, which supports the presence and development of certain pest populations (Nugraha et al., 2014), while intercropping systems consisting of refugia and repellent plants can create an environment less conducive to pest presence and development as it is thought to reduce pest's ability to locate their host plants (Jaworski et al., 2023; Acimovic et al., 2025).

Table 1. Diversity and Abundance of Insect Pests in Cayenne Pepper Cultivation under Monoculture and Intercropping Systems

Ordo Family	Species	T1	T2	T3	T4	T5	T6	Total
Orthoptera								
Gryllidae	*Gryllomorpha* sp.	14	12	6	11	10	12	65
Acrididae	*Oxya chinensis*	5	0	2	1	4	1	13
	Valanga sp.	0	0	3	0	0	0	3
	Acrididae sp.	0	0	1	0	0	2	3
Coleoptera								
Chrysomelidae	*Longitarsus* sp.	2	9	7	8	5	4	35
	Aspidomorpha sp.	0	0	0	1	0	0	1
	Aulacophora indica	1	0	0	0	1	3	5
Curculionidae	*Hypothenemus* sp.	0	0	0	0	1	1	2
Coccinellidae	*Henosepilachna* sp.	1	0	0	0	0	0	1
Diptera								
Agromyzidae	*Liriomyza* sp.	15	37	31	19	31	16	149
Chloropidae	*Conioscinella* sp.	3	17	3	2	3	2	30
Tephritidae	*Bactrocera* spp.	149	27	20	21	23	17	257
	Trupanea sp.	0	0	0	0	1	0	1
Drosophilidae	*Drosophila* sp.	0	0	0	0	0	1	1

Ordo Family	Species	T1	T2	T3	T4	T5	T6	Total
Hemiptera								
Aphididae	*Aphis* sp.	0	10	2	1	2	0	15
Psyllidae	*Psylla* sp.	4	0	0	0	0	0	4
Delphacidae	*Delphacidae* sp.	2	1	9	2	2	2	18
Lygaeidae	*Paraeucosmetus* sp.	0	0	0	1	0	0	1
	Arocatus sp.	0	0	0	0	0	1	1
Pentatomidae	*Scotinophara* sp.	0	2	1	0	2	1	6
Thysanoptera								
Thripidae	*Thrips* sp.	23	13	24	26	24	27	137
Lepidoptera								
Noctuidae	*Spodoptera litura*	1	3	5	0	0	1	10
Total Species		12	10	13	11	13	15	22
Total Individuals		220	131	114	93	109	91	758

Note: T1: Cayenne pepper monoculture; T2: Cayenne pepper + tomato intercropping; T3: Cayenne pepper + tomato + marigold intercropping; T4: Cayenne pepper + tomato + zinnia intercropping; T5: Cayenne pepper + tomato + basil intercropping; T6: Cayenne pepper + tomato + lemongrass intercropping

Furthermore, the presence of companion plants also has the potential to increase habitat complexity, which can support the development of natural enemy populations (Jaworski et al., 2023). Flowering refugia plants such as marigold and zinnia have flower structures and colors that attract natural enemies to seek nectar and pollen as energy sources, which simultaneously can suppress pest populations in the agroecosystem (Jasmi et al., 2023; Sulthoni et al., 2023). Meanwhile, aromatic plants such as basil and lemongrass can disrupt insect pest orientation because the volatile compounds produced are less preferred by pests (Damayanti & Pebriyeni, 2015; Thei, 2021).

The most dominant pest species found in this study were *Bactrocera* spp., *Liriomyza* sp., and *Thrips* sp., where these three species are the main pests of cayenne pepper that were found in almost all treatments with a relatively high number of individuals compared to other species. The high abundance of *Bactrocera* spp. indicates that observations during the generative phase of the plant provided abundant resources for the development of fruit flies. *Bactrocera* spp. is known to attack cayenne pepper fruits from the beginning of development until near harvest (Jamaluddin et al., 2020). Meanwhile, *Liriomyza* sp. dan *Thrips* sp. were found from the early vegetative phase to the generative phase of cayenne pepper plants because these pests attack young leaf tissue as a food source (Herlinda et al., 2005; Johari, 2016). The presence of these three major pest species indicates that during the growth phase, cayenne pepper was likely experiencing high biological pressure.

2. Relative Abundance of Insect Pests

The relative abundance analysis revealed that the insect pest community across all treatments was dominated by three major species, namely *Bactrocera* spp., *Thrips* sp., and *Liriomyza* sp. These species were detected in nearly all treatments and exhibited substantially higher relative abundance than the other species. In the cayenne pepper monoculture treatment, *Bactrocera* spp. was the most dominant species, accounting for 67.72% of the total pest community. This value was considerably higher than that of the other species, indicating a strong dominance of fruit flies within the insect pest community observed in this study. The high relative abundance of *Bactrocera* spp. in the monoculture system suggests that the microhabitat conditions were highly favorable for fruit fly population development, likely due to the continuous and uniform availability of food resources. This finding is consistent with Rosya and Winarto (2013), who reported that monoculture systems can promote pest outbreaks because of the abundant availability of host plants and food resources. In contrast, the intercropping treatments exhibited a more even distribution of relative abundance among pest species. In T2, T3, and T5, *Liriomyza* sp. was the most abundant species, with relative abundance values of 28.24%, 27.19%, and 28.44%, respectively. Meanwhile, in treatments T4 and T6, *Thrips* sp. showed the highest relative abundance, accounting for 27.95% and 29.67% of the pest community, respectively.

Table 2. Relative Abundance of Insect Pests in Cayenne Pepper Cultivation under Monoculture and Intercropping Systems

Species	T1	T2	T3	T4	T5	T6
Gryllomorpha sp.	6.36	9.16	5.26	11.82	9.17	13.18
Oxya chinensis	2.27	0.00	1.75	1.07	3.66	1.09
Valanga sp.	0.00	0.00	2.63	0.00	0.00	0.00
Acrididae sp.	0.00	0.00	0.87	0.00	0.00	2.19
Longitarsus sp.	0.90	6.87	6.14	8.60	4.58	4.39
Aspidomorpha sp.	0.00	0.00	0.00	1.07	0.00	0.00
Aulacophora indica	0.45	0.00	0.00	0.00	0.91	3.29
Hypothenemus sp.	0.00	0.00	0.00	0.00	0.91	1.09
Henosepilachna sp.	0.45	0.00	0.00	0.00	0.00	0.00
Liriomyza sp.	6.81	28.24	27.19	20.43	28.44	17.58
Conioscinella sp.	1.36	12.97	2.63	2.15	2.75	2.19
Bactrocera spp.	67.72	20.61	17.54	22.58	21.10	18.68
Trupanea sp.	0.00	0.00	0.00	0.00	0.91	0.00
Drosophila sp.	0.00	0.00	0.00	0.00	0.00	1.09
Aphis sp.	0.00	7.63	1.75	1.07	1.83	2.19
Psylla sp.	1.81	0.00	0.00	0.00	0.00	0.00
Delphacidae sp.	0.90	0.76	7.89	2.15	1.83	2.19
Paraeucosmetus sp.	0.00	0.00	0.00	1.07	0.00	0.00
Arocatus sp.	0.00	0.00	0.00	0.00	0.00	1.09
Scotinophara sp.	0.00	1.52	0.87	0.00	1.83	1.09
Thrips sp.	10.45	9.92	21.05	27.95	22.01	29.67
Spodoptera litura	0.45	2.29	4.38	0.00	0.00	1.09
Total	100%	100%	100%	100%	100%	100%

Note: T1: Cayenne pepper monoculture; T2: Cayenne pepper + tomato intercropping; T3: Cayenne pepper + tomato + marigold intercropping; T4: Cayenne pepper + tomato + zinnia intercropping; T5: Cayenne pepper + tomato + basil intercropping; T6: Cayenne pepper + tomato + lemongrass intercropping

The decline in relative abundance of *Bactrocera* spp. from 67.72% in monoculture to approximately 17–22% across all intercropping treatments represents one of the important findings of this study. These results indicate that increasing plant species diversity can reduce the dominance of the main pest without completely eliminating the presence of the species. It can be said that intercropping system treatments not only suppress pest populations but also change the insect community structure to become more balanced (Yasurruni, 2018). In the intercropping treatment incorporating a refugia plant (marigold), the distribution of relative abundance was more evenly distributed than in the other treatments. This pattern is likely associated with the role of marigold as a flowering plant that provides food resources for natural enemies (Alprilia et al., 2024). A greater abundance of natural enemies within an agroecosystem can enhance the effectiveness of natural pest regulation through their function as biological control agents (Setiawati et al., 2023). Consequently, pest populations can be suppressed, thereby reducing the excessive dominance of particular pest species and promoting a more balanced insect community structure (Sianipar et al., 2015).

Meanwhile, the lemongrass treatment resulted in the lowest overall pest abundance, but *Thrips* sp. still had the highest relative proportion. This condition indicates that lemongrass is more effective in suppressing populations of *Bactrocera* spp. and *Liriomyza* sp. compared to *Thrips* sp. The increase in relative proportion of *Thrips* sp. in that treatment does not mean its population increased, but was caused by a more drastic decline in other species populations. Ecologically, this pattern shows that each type of companion plant has a different mechanism in influencing the insect pest community. Refugia plants tend to work through increased natural enemy activity (Asmoro et al., 2021; Setiawati et al., 2023), while repellent plants work through disruption of host-seeking behavior using volatile compounds (Deletre et al., 2016; Acimovic et al., 2025). Arsi et al. (2023) stated that aromatic or repellent plant that contains various compounds exhibit biological ectivities against insects, acting as repellents, attractants, toxins (contact poisons), fumigants (respiratory poisons), antifeedants, etc.

3. Shannon-Wiener Diversity Index (H'), Evenness Index (E), and Simpson Dominance Index (D)

The analysis of the Shannon–Wiener diversity index (H'), evenness index (E), and Simpson dominance index (D) demonstrated that the implementation of intercropping systems integrated with refugia and repellent plants influenced the stability of the insect pest community. These three indices are important indicators for evaluating community balance within an agroecosystem. The Shannon–Wiener diversity index values across all treatments were classified as moderate, ranging from 1.23 to 2.06. Although all treatments fell within the moderate diversity category, clear differences were observed between the monoculture and intercropping systems. The highest H' value was recorded in the cayenne pepper + tomato + marigold treatment (T3), reaching 2.06, whereas the lowest value was observed in the cayenne pepper monoculture treatment (T1), with an H' value of 1.23. The high diversity index in T3 indicates that the inclusion of refugia plants enhanced the diversity of the insect pest community. The moderate diversity index values observed in both monoculture and intercropping systems suggest that the cayenne pepper agroecosystem was relatively stable, likely reflecting a balance between pest populations and their natural enemies (Januarisya et al., 2023).

The presence of flowering plants provides additional resources that can be utilized by various arthropod groups, thereby enriching community structure within the agroecosystem (Prabowo et al., 2021; Jasmi et al., 2023). Furthermore, increased activity of natural enemies may suppress the dominance of particular pest species, allowing a greater number of species to coexist within the same habitat (Nawir et al., 2021). In contrast, the relatively low H' value observed in the monoculture treatment indicates that the community was dominated by only a few species. Such conditions reflect a less stable agroecosystem because fluctuations in the population of a dominant species can have substantial effects on the overall community structure and ecological balance (Nugraha et al., 2014; Januarisya et al., 2023).

Table 3. The analysis of the Shannon–Wiener diversity index (H'), evenness index (E), and Simpson dominance index (D)

Treatment	H'	Category	E	Category	D	Category
T1	1.23	Moderate	0.49	Moderate	0.47	Low
T2	1.96	Moderate	0.85	Moderate	0.16	Low
T3	2.06	Moderate	0.80	Moderate	0.16	Low
T4	1.84	Moderate	0.76	Moderate	0.19	Low
T5	1.94	Moderate	0.75	Moderate	0.18	Low
T6	2.04	Moderate	0.75	Moderate	0.17	Low

The evenness value (E) showed a similar pattern. T2 had the highest evenness value of 0.85, while monoculture had the lowest value of 0.49. The moderate evenness value indicates that the distribution of individuals among species was relatively balanced (Mursyidin et al., 2025). Thus, no single species dominated excessively. Conversely, the Simpson dominance index (D) showed a pattern opposite to the diversity index (Januarisya et al., 2023). The highest D value was found in monoculture (0.47), while the lowest was found in T2 and T3 (0.16). The high dominance value in monoculture indicates that most individuals in the community came from one dominant species, namely *Bactrocera* spp. Conversely, the low dominance values observed in the intercropping systems suggest a more balanced and stable community structure (Alprilia et al., 2024).

Overall, increasing vegetation complexity through the integration of intercropping systems, refugia, and repellent plants resulted in a trend of higher community diversity and evenness, accompanied by reduced dominance of particular species (Handayani et al., 2019). These conditions reflect the development of a more stable agroecosystem that is better able to withstand pest population outbreaks than monoculture systems (Lizmah et al., 2018). Among all treatments evaluated, the combination of cayenne pepper–tomato, and marigold produced the most stable community structure, as indicated by the highest Shannon–Wiener diversity index (H') and the lowest Simpson dominance index (D). In contrast, the combination of cayenne pepper, tomato, and lemongrass was the most effective treatment for suppressing overall pest abundance. Although no inferential analysis was performed, the observed pattern suggests that integrating refugia and repellent plants into the intercropping system may contribute to reducing insect pest abundance compared with the monoculture treatment.

CONCLUSIONS

The application of cayenne pepper intercropping with tomato, refugia, and repellent plants has the potential to influence insect pest diversity and abundance. A total of 758 individual insect pests belonging to 7 orders, 16 families, and 22 species were successfully identified in this study. The dominant species were *Bactrocera* spp., *Liriomyza* sp., and *Thrips* sp. The cayenne pepper monoculture system resulted in the highest pest abundance and the greatest level of species dominance, whereas the intercropping systems reduced pest populations while simultaneously enhancing insect community diversity. The intercropping system integrated with refugia and repellent plants consistently showed the lowest observed pest abundance and the highest insect diversity, indicating its potential for ecological pest management in cayenne pepper cultivation.

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