J. Trop. Plant Pests Dis.
Vol. 25, No. 1, March 2025
Pages: 1–8

ISSN: 1411-7525
E-ISSN: 2461-0399
DOI : 10.23960/j.hptt.1251-8

RESEARCH PAPER

The spesies diversity of arthropods in *surjan* and conventional farming systems in the Special Region of Yogyakarta

Wagiyana[1], Fariz Kustiawan Alfarisy[1], Suharto[1], Bakhroini Habriantono[1], Mohammad Nur Khozin[2], & Febery Hery Suandana[2]

Manuscript received: 1 May 2024. Revision accepted: 31 July 2024. Available online: 15 January 2025.

ABSTRACT

An ecosystem is the relationship between insects and the environment in carrying out life processes. The majority of insects are herbivores, and plants serve as their main hosts. Plants also secrete hormone compounds that are favored by arthropods as both a food source and a host for survive. Based on their nature, arthropods are divided into pests and natural enemies. The *surjan* system is one of the agroecosystem modifications for sustainable agriculture. The study aimed to assess arthropod spesies diversity in different cropping systems. Monitoring was conducted on *surjan* and conventional land, using several types of traps, including pitfall traps, yellow traps, and pheromone traps. The diversity of arthropods in an ecosystem serves as an indicator of environmental health. This research provides recommendation for managing arthropods, whether as pests or natural enemies. The highest diversity index value was found in the conventional system, with the Shannon_H' value of of 1.57 for trapping 1, 1.27 for trapping 2, 2.06 for trapping 3, and 1.20 for trapping 4. The species diversity (H' > 1) value was classified in the medium category. The results of morphological identification revealed two species with the highest abundance: *Bactrocera* sp. and *Atherigona* sp. The effectiveness of yellow traps was higher compared to other types of trap, capturing a total of 280 species of pests.

Key words: abundance, ecosystem, modification, monitoring, trap

INTRODUCTION

Arthropoda is one of the largest phyla, with more species compared to other phyla. Arthropods are divided into ten classes, including insects. Insects are further divided into 29 orders, and almost all orders are associated with plants. Herbivores in the ecosystem are classified based on their status isto into two categories: pests and natural enemies. Both are associated with plants because plants release hormonal compounds that can attract insects (Mukwevho et al., 2024).

The presence of arthropods in plant ecosystems is influenced by the cultivation system (Gong et al., 2023; Norris et al., 2016). Significant differences exist between intensive agricultural systems and sustainable agricultural systems (Dutta et al., 2023; Hevia et al., 2021; Peng et al., 2023). An intensive cultivation system, or monoculture, is a method used to increase plant productivity by employing fertilizers and pesticides on a massive scale. In contrast, a sustainable agricultural system focuses on cultivation practices that prioritize environmental health. Without relying on synthetic materials, research has shown that secondary metabolite compounds from the botanical pesticide derived from kapok leaves can help control of canker diseases in dragon fruit plants (Masnilah et al., 2021). Additionally, entomopathogenic microorganisms are promosing candidates for integrated pest management in cabbage cultivation (Habriantono et al., 2023).

The *surjan* system is a cultivation technique based on local wisdom from the Special Region of Yogyakarta (Rijanta, 2018). This system is applied to rice fields, characterized by differences in land height between plantings. Land preparation is adjusted to the height and type of plant. A paddy field ecosystem under this system consists of various cultivated plants, making it comparable to polyculture with varying land elevations. The *surjan* system in Yogyakarta was developed to address water management challenges. Higher land plots are designated for planting secondary crops, while lower plots are used for rice and other aquatic plants.

Corresponding author:

Fariz Kustiawan Alfarisy (farizkustiawan@unej.ac.id)

[1]Department of Plant Protection, Faculty of Agriculture, University of Jember. Kalimantan Street 37 Tegalboto, 68121, Jember, East Java, Indonesia
[2]Department of Agronomy, Faculty of Agriculture, University of Jember. Kalimantan Street 37 Tegalboto, 68121, Jember, East Java, Indonesia

Many *surjan* fields also incorporate refugia, which serve as hosts for natural enemies. Flowering plants, such as sunflowers, are particularly attractive to insects because they contain phytochemical metabolite compounds that draw them in (Murali-Baskaran et al., 2022). Additionally, land management using the *surjan* system can disrupt the bioecological life cycle of pests. Polyculture planting is an effective alternative to prevent primary pest outbreaks. Species diversity, abundance, species composition, and the biodiversity index in *surjan* farming were significantly improved compared to *lembaran* farming (Trisnawati et al., 2024).

This research aims to monitor the diversity of arthropods in conventional and *surjan* systems. The performance of the arthropod biodiversity index serve as an indicator of ecosystem sustainability. The study specifically aims to assess arthropod spesies diversity across different cropping systems.

MATERIALS AND METHODS

Research Site. The research was conducted in the Special Region of Yogyakarta at two locations: Kulonprogo Regency (*surjan* system) and Bantul Regency (conventional system) (Figure 1). Crop cultivated in the *surjan* system consist of polyculture plants, combining food and horticultural crops. In contrast, conventional land typically features monoculture crops, primarily paddy field. Sampling was conducted from June-August 2022.

Traps Construction

Pitfall Trap. The pitfall trap was constructed using a PVC bottle with a height of 10 cm and a diameter of 6.5 cm. It was planted into the ground to match the depth of the bottle so that its opening was flush with the ground surface. Pitfall traps were used to capture non-winged insects in the ecosystem. Each trap contained a Texapone solution (sodium laureth sulfate) (Inti Karya, Indonesia) to kill insects that fell into it. A 20 g amount of Texapone solution was dissolved in 250 mL of water.

The pitfall traps were installed along the rice field embankments in diagonal alignments at four coordinate points (Figure 2). Captured arthropods were transferred into 20 mL vials containing 70% ethanol for preservation.

Yellow Trap. Insects are more attracted to lighter

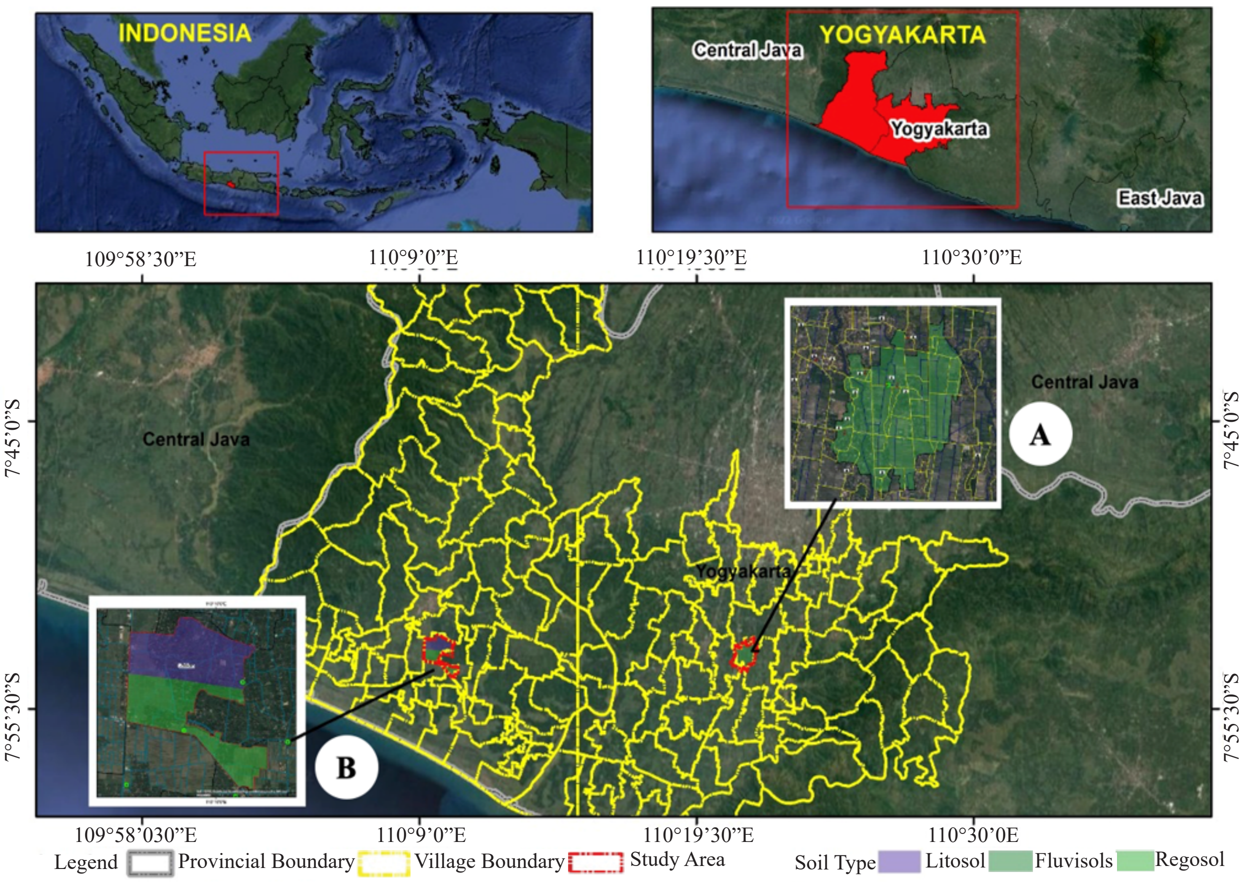

Figure 1. Research sites. (A) Bantul Regency; (B) Kulonprogo Regency.

colors, with the level of color brightness significantly affecting their attractiveness (Bolliger et al., 2022; Kivelä et al., 2023). The yellow trap used in this study measured 20 cm × 25 cm and was manufactured by Anhui Haojintong Electronic Technology Co., Ltd, China. Installation was performed in the morning, and observations were conducted over three days. Yellow traps were positioned at mid-plant height.

Insects attracted to the color yellow include aphids members of the Lepidoptera order, whiteflies, and *Thrips* sp. Trapped arthropods samples were collected using a brush and transferred into vials containing 70% ethanol for preparation.

Pheromone Trap. Pheromone traps are designed to catch insects using attractant compounds, primarily targeting males. The active ingredient used is this study was Methyl Eugenol (ME) ($C_{12}H_{24}O_2$) at a concentration of 800 g/L. This compound is particularly effective at attracting *Bactrocera* sp. and *Dacus* sp.

A total of 0.25 mL of Methyl Eugenol was injected into a cotton ball, which was then placed inside a tube containing 100 mL of 70% alcohol. The traps were installed diagonally between the plants to maximize coverage.

Identification of Species Arthropods. Specimen collected from the trapping results were stored and examined under a microscope. Arthropod identification was conducted using the reference book “Introduction to the Identification of Insects and Related Arthropods” by observing arthropod morphology and using dichotomous keys.

Data and Statistical Analysis. The collected data were tabulated in Microsoft Excel. Further analysis to measure diversity indicators was cunducted using PAST Version 4.11, a software tool for analytical science data. PAST can be accessed through the Natural History Musem’s website (https://www.nhm.uio.no/english/research/resources/past/).

This tool enables comprehensive analysis, including multivariate data exploration, biodiversity indices calculation, and Principal Component Analysis (PCA) modeling.

RESULTS AND DISCUSSION

The cultivation system influences the species composition within an ecosystem. The presence of arthropods contributes to maintaining the balance of the rice field ecosystem. Based on Table 1, all arthropods collected were analyzed and identified through morphological observations and a guidebook for classification.

Taxa refers to the grouping of species based on similarities in scientific names. The level of taxa accross several trapping results was found to be quite varied. Taxa describe groups organisms sharing common characteristics and morphology. The total number of individuals represents the total number of species identified.

The overall trapping results showed a high level of species dominance. Dominance indicates the abundance of a particular species within an ecosystem. The dominance index reflects the influence of a species in a community, with a value > 0.5 signifying

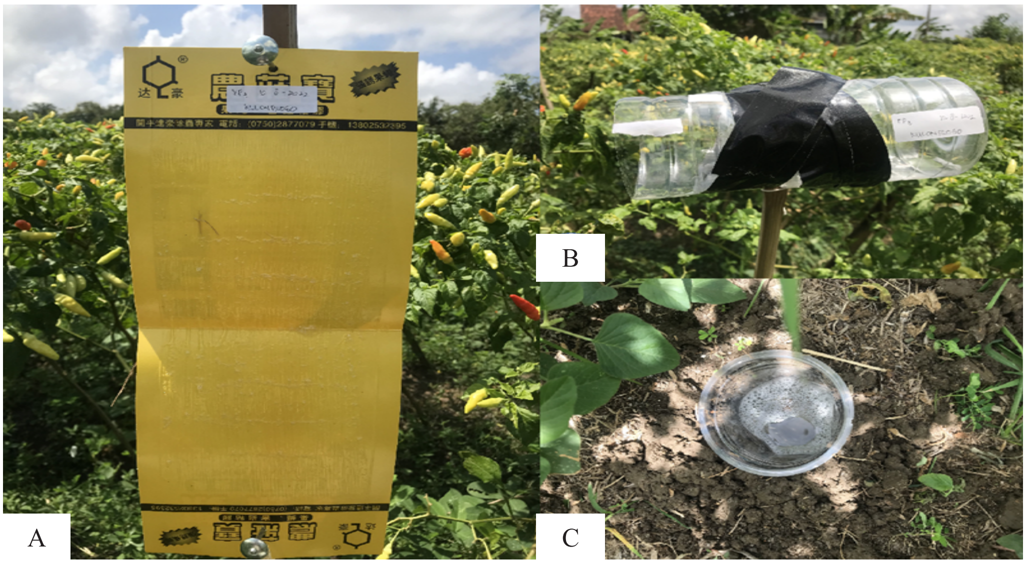

Figure 2. Trapping design. A. Yellow trap; B. Pheromone trap; C. Pitfall trap.

high dominance. Trapping results from sessions 1–4 recorded dominance index values exceeding 0.5, confirming the presence dominant species.

Several factors may contribute to a high dominance index within a community, including planting system patterns (Brandmeier et al., 2021). Additionally, the use of synthetic fertilizers influences the diversity and abundance of soil arthropods (Nsengimana et al., 2023). Similar research supports the finding that plants heterogeneity affects the dynamics of above-ground arthropod diversity (Eckert et al., 2023).

In diversity indicators, the Shannon diversity index is calculated based on the proportion of each species collected relative to the total number of species. The diversity level in conventional systems falls within the medium category. A Shanon_H (H') value of H' < 1 is categorized as low, 1 < H' < 3 as medium, and H' > 3 as high. According to Table 1, the diversity index in the *surjan* planting system is lower than in the conventional system. The total number of taxa identified in the *surjan* system is also lower than in the conventional system. The average Shannon_H diversity index in the *surjan* is < 1, placing it in the low category.

Biodiversity in conventional planting systems performs better overall, within a higher level of arthropod species diversity. However, considering the functional role of species in cultivation, the *surjan* system demostrates better ecological performed. The number of natural enemies, such as predators and parasitoids, is greater in the *surjan* system compared to the conventional system.

The results of the PCA (Principal Component Analysis) were used to identify the abundance and diversity of species based on cultivation systems. The biplot graph (Figure 3) shows the relationships among the four trapping points (Trapping 1, 2, 3, and 4). The traps were placed diagonally across the landat upper, middle, and lower positions. A stronger relationship among trapping points indicates greater species similarity. Traping Point 4 was closer to the cluster associated with *Bactrocera* sp., suggesting that more individuals of this species were trapped there compared to other points. The dominance of *Bactrocera* sp. was higher than other species. Behaviorally, *Bactrocera* sp. is often associated with horticultural plants. The trapping installation in the Bantul Regency area was located among rice plants, but historically, the land had been used for chili cultivations before rice planting. This previous land use likely contributed to the still-abundant population of *Bactrocera* sp.

In Figure 3b, the total number of arthropods in the *surjan* system was lower than in the conventional

Table 1. Diversity index of conventional cropping systems

Diversity Index	Conventional cropping systems				*Surjan* cropping system			
	Trap 1	Trap 2	Trap 3	Trap 4	Trap 1	Trap 2	Trap 3	Trap 4
Taxa_S	10	6	13	5	5	4	4	3
Individuals	72	71	94	53	59	46	29	24
Dominance_D	0.357	0.315	0.159	0.344	0.53	0.45	0.42	0.69
Simpson_1-D	0.64	0.68	0.84	0.65	0.46	0.54	0.57	0.3
Shannon_H	1.575	1.278	2.063	1.2	0.94	0.95	1.06	0.58

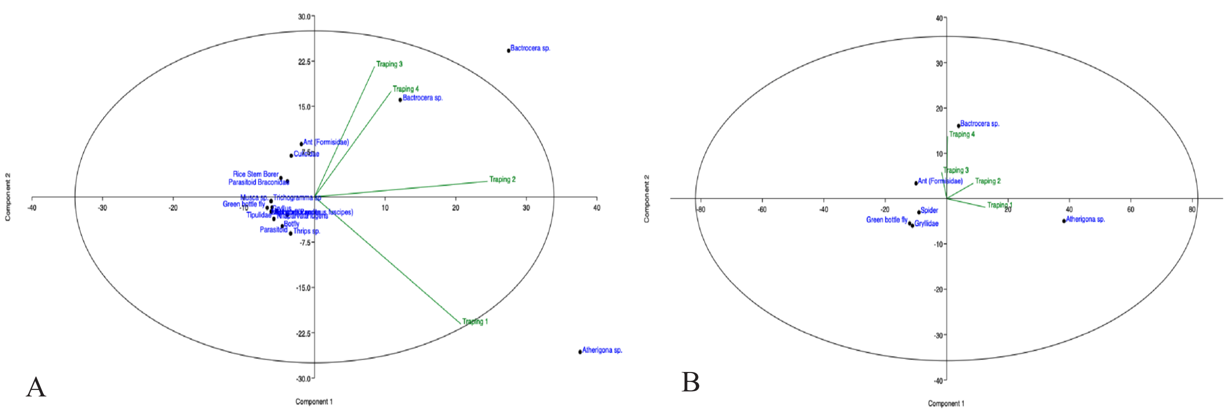

Figure 3. Principal Component Analysis to diversity of arthropod. A. Conventional system; B. *Surjan* system.

planting system. At the time of observation, the *surjan* system was in the chili and rice planting season. *Bactrocera* sp. remained the most abundance species. However, in the *surjan* system, the diversity of natural enemies was higher compared to the conventional planting systems. The diversity index in the *surjan* system was lower than in the conventional systems.

In the PCA biplot analysis at the 95% confidence level, the relationship between the trapping quantity and species abundance appeared to be quite distant. This suggests that the *surjan* system incorporates cultivation technology with agroecosystem engineering. The presence of refugia plants may influence the effectiveness of trapping method. According to a study by Ganser et al. (2019), refugia plants such as sunflowers are considered more effective than ecological traps in attracting arthropods.

Cluster analysis was conducted to group the collected arthropod collections and determine their relationship. In addition to identifying relationships at the taxonomic level, kindship relationships were also analyzed based on shared characteristics and associations with cultivated plants. The clustering results revealed a strong correlation between species presence and community compotion (Figure 4a). In the conventional system, three clusters were identified: cluster one: parasitoids (Braconidae); cluster two: ants, *Culicidae*, rice stem borer (*Scirpophaga* sp.) and *Bactrocera* sp.; cluster three: a combination of Botfly, an unidentified parasitoid, *Nephotettix* sp., *Nilaparvata lugens*, *Tipulidae*, *Thrips* sp., *Leptocorisa acuta*, and *tomcat* (local Indonesia name for *Paederus fuscipes*).

Figure 4b depicts the clustering of arthropods collected from the *surjan* system. The multivariate clustering results revealed two clusters: the first cluster consisted of the Green Bottle Fly, while the

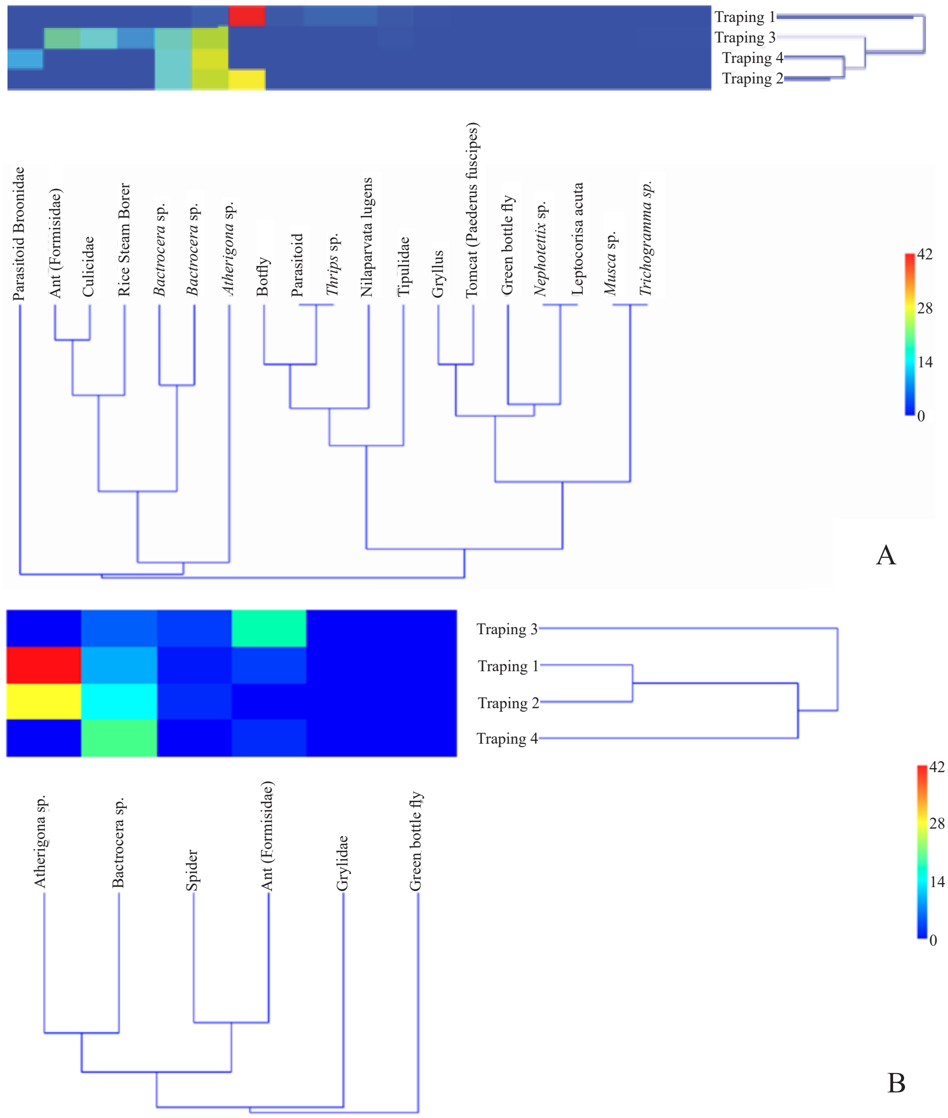

Figure 4. Homogeneity of the diversity arthropod to kind of trapping through clustering analysis. A. Conventional system; B. *Surjan* system.

second cluster included *Atherigona* sp., Gryllidae, Ants (Formicidae) and *Bactrocera* sp. Vertical color indicators in the figure represent the total number of each species species collected. From these two clusters, it was observed that both were dominated by pests, namely *Bactrocera* sp., and *Atherigona* sp. (Figure 5). *Bactrocera* sp. is a fruit fly pest known to attack horticultural plants. Male fruit flies are particularly attracted to compounds released by plants (Jayanthi & Verghese, 2011; Kim & Kim, 2018; Miyazaki et al., 2018).

In addition to synthetic pesticides, trapping can serve as an effective for managing plant pests. Trapping methods are cost-effective, accessible, and utilize pest traits and behaviours to control populations (Balbuena et al., 2023; Christensen et al., 2022). Figure 6 illustrates that yellow traps captured more arthropods than pitfall traps and pheromone traps.

Insects are generally more attacted to yellow light, with members of the orders Lepidoptera and Hymenoptera being particularly dominant (Shin et al., 2020). Arthropods collected using yellow traps in both study locations were more effectively captured, especially pest species. However, some natural enemies were also trapped, albeit in smaller numbers.

CONCLUSION

The biodiversity index in the conventional system is higher than in the *surjan* system, with a Shannon_H' > 1 index value in the medium category. However, the high biodiversity value does not correlate with the presence of pests or natural enemies. There is a relationship between the type of trapping used and the clustering of species collected. The dominance value of species in a population is closely linked to the cultivation process and the use of synthetic materials. *Bactrocera* sp. and *Atherigona* sp. are the species with the greatest abundance. Yellow traps are more effective than other types of traps, capturing a total of 280 pest species. This study provides a model for agroecosystem management in surjan systems for sustainable integrated pest management.

ACKNOWLEDGMENTS

The research team would like to thank LP2M Jember University for funding the research under the

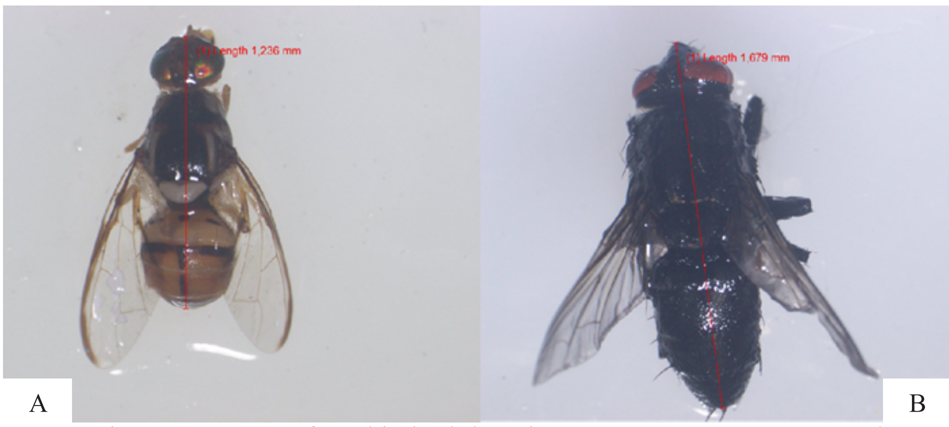

Figure 5. Dominant pests were found in both locations. A. *Bactrocera* sp.; B. *Atherigona* sp.

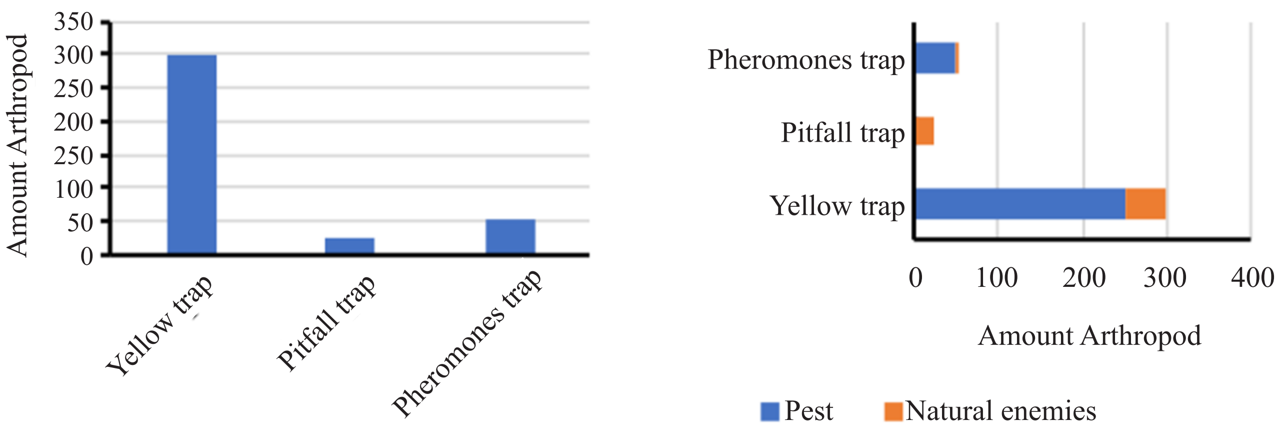

Figure 6. Effectiveness of installing trap types.

KERIS DIMAS research scheme.

FUNDING

This research was funded under the KERIS DIMAS research scheme, with Contract Number 4420/ UN25.3.1/LT 2022.

AUTHORS' CONTRIBUTIONS

W and FKA conceived and planned the experiment. BH and MNK conducted field observations and identified arthropods in the laboratory. S and FHS worked on data analysis. FKA and W wrote and proofread the manuscript. All authors have read and approved the final manuscript.

COMPETING INTEREST

The authors declare no conflict of interest.

REFERENCES

Balbuena D, Inga G, Ponce L, Zuniga R, & Kays R. 2023. Olingos do eat insects: Records of nocturnal mammals preying on arthropods in arboreal live-capture traps. *Food Webs*. 36: e00298. https://doi.org/10.1016/j.fooweb.2023.e00298

Bolliger J, Haller J, Wermelinger B, Blum S, & Obrist MK. 2022. Contrasting effects of street light shapes and LED color temperatures on nocturnal insects and bats. *Basic Appl. Ecol.* 64: 1–12. https://doi.org/10.1016/j.baae.2022.07.002

Brandmeier J, Reininghaus H, Pappagallo S, Karley AJ, Kiær LP, & Scherber C. 2021. Intercropping in high input agriculture supports arthropod diversity without risking significant yield losses. *Basic Appl. Ecol.* 53: 26–38. https://doi.org/10.1016/j.baae.2021.02.011

Christensen JW, Strøm CG, Nicová K, de Gaillard CL, Sandøe P, & Skovgård H. 2022. Insect-repelling behaviour in horses in relation to insect prevalence and access to shelters. *Appl. Anim. Behav. Sci.* 247: 105560. https://doi.org/10.1016/j.applanim.2022.105560

Dutta SK, Laing A, Kumar S, Shambhavi S, Kumar S, Kumar B, Verma DK, Kumar A, Singh RG, & Gathala M. 2023. Sustainability, productivity, profitability and nutritional diversity of six cropping systems under conservation agriculture: A long term study in eastern India. *Agric. Syst.* 207: 103641. https://doi.org/10.1016/j.agsy.2023.103641

Eckert M, Gaigher R, Pryke JS, Janion-Scheepers C, & Samways MJ. 2023. High trait diversity among soil arthropods allows their survival in a heterogeneous eco-agricultural mosaic. *Soil Biol. Biochem.* 186: 109180. https://doi.org/10.1016/j.soilbio.2023.109180

Ganser D, Knop E, & Albrecht M. 2019. Sown wildflower strips as overwintering habitat for arthropods: Effective measure or ecological trap?. *Agric. Ecosyst. Environ.* 275: 123–131. https://doi.org/10.1016/j.agee.2019.02.010

Gong S, Zhou X, Zhu X, Huo J, Faghihinia M, Li B, & Zou Y. 2023. Organic rice cultivation enhances the diversity of above-ground arthropods but not below-ground soil eukaryotes. *Agric. Ecosyst. Environ.* 347: 108390. https://doi.org/10.1016/j.agee.2023.108390

Habriantono B, Suharto S, Wagiyana W, Hoesain M, Jatmiko MW, Prastowo S, Pradana AP, Nurdika AAH, & Alfarisy FK. 2023. Toxicology of Nuclear Polyhedrosis Virus, botanical and synthetic pesticides on mortality rate of *Crocidolomia binotalis* (Zeller). *Baghdad. Sci. J.* 20(1): 17–25. https://doi.org/10.21123/bsj.2022.6154

Hevia V, Carmona CP, Azcárate FM, Heredia R, & González JA. 2021. Role of floral strips and semi-natural habitats as enhancers of wild bee functional diversity in intensive agricultural landscapes. *Agric. Ecosyst. Environ* . 319: 1–9. https://doi.org/10.1016/j.agee.2021.107544

Jayanthi PDK & Verghese A. 2011. Host-plant phenology and weather based forecasting models for population prediction of the oriental fruit fly, *Bactrocera dorsalis* Hendel. *Crop Prot.* 30(12): 1557–1562. https://doi.org/10.1016/j.cropro.2011.09.002

Kim SB & Kim DS. 2018. A tentative evaluation for population establishment of *Bactrocera dorsalis* (Diptera: Tephritidae) by its population modeling: Considering the temporal distribution of host plants in a selected area in Jeju, Korea. *J. Asia. Pac. Entomol.* 21(2): 451–465. https://doi.org/10.1016/j.aspen.2018.01.022

Kivelä L, Elgert C, Lehtonen TK, & Candolin U. 2023. The color of artificial light affects mate attraction in the common glow-worm. *Sci. Total Environ.* 857(3): 159451. https://doi.org/10.1016/j.scitotenv.2022.159451

Masnilah R, Budi ION, Pradana AP & Alfarisy FK. 2021. Secondary metabolite *Ceiba pentandra* Gaertn. as biological control to canker disease on dragon fruit. *J. Trop. Life Sci.* 11(3): 331–337. https://doi.org/10.11594/jtls.11.03.10

Miyazaki H, Otake J, Mitsuno H, Ozaki K, Kanzaki R, Chui-Ting Chieng A, Kah-Wei Hee A, Nishida R, & Ono H. 2018. Functional characterization of olfactory receptors in the Oriental fruit fly *Bactrocera dorsalis* that respond to plant volatiles. *Insect Biochem*. *Mol. Biol.* 101: 32–46. https://doi.org/10.1016/j.ibmb.2018.07.002

Mukwevho L, Ndlovu M, Chikowore G, Dalu T, Mutamiswa R, & Chidawanyika F. 2024. Responses of ground-dwelling arthropods to long-term prescribed fire regimes in a savanna-protected area. *Rangel. Ecol. Manag.* 95: 46–65. https://doi.org/10.1016/j.rama.2024.04.008

Murali-Baskaran RK, Mooventhan P, Das D, Dixit A, Sharma KC, Senthil-Nathan S, Kaushal P, & Ghosh PK. 2022. The future of plant volatile organic compounds (pVOCs) research: Advances and applications for sustainable agriculture. *Environ. Exp. Bot.* 200: 104912. https://doi.org/10.1016/j.envexpbot.2022.104912

Norris SL, Blackshaw RP, Dunn RM, Critchley NR, Smith KE, Williams JR, Randall NP, & Murray PJ. 2016. Improving above and below-ground arthropod biodiversity in maize cultivation systems. *Appl. Soil. Ecol.* 108: 25–46. https://doi.org/10.1016/j.apsoil.2016.07.015

Nsengimana V, de Dieu Nsenganeza J, Hagenimana T, & Dekoninck W. 2023. Impact of chemical fertilizers on diversity and abundance of soil-litter arthropod communities in coffee and banana plantations in southern Rwanda. *CRSUST.* 5: 100215. https://doi.org/10.1016/j.crsust.2023.100215

Peng L, Xu XJ, Liao XF, Liu JM, & Chen JZ. 2023. *Ampelocalamus luodianensis* (Poaceae), a plant endemic to karst, adapts to resource heterogeneity in differing microhabitats by adjusting its biomass allocation. *GECCO. Conserv.* 41: e02374. https://doi.org/10.1016/j.gecco.2023.e02374

Rijanta R. 2018. Sustainability of the *Sawah Surjan* agricultural systems in Depok Village, Panjatan Subdistrict, Kulonprogo Regency, Yogyakarta Special Province. *Forum Geografi.* 32(2): 109–118. https://doi.org/10.23917/forgeo.v32i2.5798

Shin YK, Kim SB, & Kim DS. 2020. Attraction characteristics of insect pests and natural enemies according to the vertical position of yellow sticky traps in a strawberry farm with high-raised bed cultivation. *J. Asia. Pac. Entomol.* 23(4): 1062–1066. https://doi.org/10.1016/j.aspen.2020.08.016

Trisnawati DW, Nurkomar I, Antono A, & Puspitasari E. 2024. Diversity and community structure of predators in *surjan* (polyculture) and lembaran (monoculture) paddy fields. *J. Trop. Plant Pests. Dis*. 24(2): 162–172. https://doi.org/10.23960/jhptt.224162-172