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EFFECT OF REFUGIA PLANTS *Tagetes erecta* AND *Zinnia* sp. ON RICE STEM BORER INFESTATION AND EGG PARASITOID EMERGENCE

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ABSTRACT

Rice stem borer is an important pest of rice. Damage intensity and yield loss can reach about 90% and 30%, respectively. The concept of sustainable agriculture needs to be applied in controlling this pest by agro-ecosystem engineering through planting refugia plants. This study was conducted to determine the effect of *Tagetes erecta* and *Zinnia* sp. as refugia plants in rice plants on the damage caused by rice stem borers and the emergence of egg parasitoids. This study used a Split Plots Design, the main plots were types of refugia plants i.e. *T. erecta*, *Zinnia* sp. and without refugia plants (control). The sub plots were rice varieties i.e., Ciherang and Inpari 32. Rice was planted in a plot size 4 m x 7 m and the refugia plants were planted along side of the rice plots. There were four replications in this study. The results showed that the percentage of rice clumps infested by rice stem borer was difference significantly caused by types of refugia plants at 6 weeks after planting (F=44.46; df=2,6; $P<0.05$) and 11 weeks after planting (F=27.38; df=2,6; $P<0.05$). Percentage of rice clumps infested by rice stem borers was higher in the control treatment (22.50 and 19.17% respectively) at 6 and 11 weeks after planting (WAP) compared to the refugia treatment of *T. erecta* was 4.17% at 6 and 11 WAP. There was 2.5% rice clump infested stem borer at 6 WAP and no clump rice infested at 11 WAP at rice plot with *Zinnia* sp. as refugia treatment. The number of emerging egg parasitoids was significantly higher from stem borer eggs obtained from rice plants surrounded by refugia plants compared to stem borer eggs obtained from rice plants without refugia plants (F = 6.938; df = 2.6; $P<0.05$). The number of parasitoids emerged from stem borer eggs obtained from rice with refugia T. *erecta* and *Zinnia* sp. was an average of 37.50 and 43.88 parasitoids, significantly more than the control treatment which was an average of 17.88 parasitoids. Meanwhile, Ciherang and Inpari 32 varieties generally showed responses that were not significantly different of parasitoids number (F=0.22; df=1,9; $P>0.05$). The parasitoid that emerged from stem borer eggs was *Telenomus* sp. The present study showed that the refugia plants *T. erecta* and *Zinnia* sp. are the promising candidate as refugia plants to control rice stem borer.

Keywords: Agro-ecosystem engineering; rice plant; refugia plant; rice stem borer; parasitoid

ABSTRAK

Pengorek batang padi merupakan perosak penting padi. Keamatan kerosakan dan kehilangan hasil boleh mencapai kira-kira 90% dan 30%. Konsep pertanian lestari perlu diterapkan dalam mengawal perosak ini secara kejuruteraan agroekosistem melalui penanaman tumbuhan refugia. Kajian ini dijalankan untuk menentukan kesan *Tagetes erecta* dan *Zinnia* sp. sebagai tumbuhan refugia dalam tanaman padi atas kerosakan yang disebabkan oleh pengorek batang padi dan kemunculan telur parasitoid. Kajian ini menggunakan Reka Bentuk Petak Berpisah, plot utama adalah jenis tumbuhan refugia iaitu, *T. erecta*, *Zinnia* sp. dan tanpa tumbuhan refugia (kawalan). Sub plot adalah varieti padi iaitu Ciherang dan Inpari 32. Padi ditanam dalam petak bersaiz 4 m x 7 m dan pokok refugia ditanam di tepi petak padi. Terdapat empat replikasi dalam kajian ini. Hasil kajian menunjukkan peratusan rumpun padi yang diserang pengorek batang padi adalah perbezaan yang ketara disebabkan oleh jenis tumbuhan refugia pada 6 minggu selepas penanaman (F=44.46; df=2,6; *P<0.05*) dan 11 minggu selepas penanaman (F=27.38; df=2,6*; P<0.05*). Peratusan rumpun padi yang diserang pengorek batang padi adalah lebih tinggi dalam rawatan kawalan (masing-masing 22.50 dan 19.17%) pada 6 dan 11 minggu selepas penanaman (WAP) berbanding rawatan refugia *T. erecta* ialah 4.17% pada 6 dan 11 WAP. Terdapat 2.5% rumpun padi yang diserang pengorek batang pada 6 WAP dan tiada rumpun padi yang diserang pada 11 WAP di petak padi dengan *Zinnia* sp. sebagai rawatan refugia. Bilangan parasitoid telur yang muncul adalah lebih tinggi secara signifikan daripada telur pengorek batang yang diperoleh daripada pokok padi yang dikelilingi oleh tumbuhan refugia berbanding dengan telur pengorek batang yang diperoleh daripada pokok padi tanpa tumbuhan refugia (F = 6.938; df = 2.6; *P<0.05*). Bilangan parasitoid muncul daripada telur pengorek batang yang diperoleh daripada beras dengan refugia *T. erecta* dan *Zinnia* sp. adalah purata 37.50 dan 43.88 parasitoid, lebih ketara daripada rawatan kawalan iaitu purata 17.88 parasitoid. Manakala varieti Ciherang dan Inpari 32 secara amnya menunjukkan tindak balas yang tidak berbeza secara signifikan bagi bilangan parasitoid (F=0.22; df=1,9; *P>0.05*). Parasitoid yang muncul daripada telur pengorek batang ialah *Telenomus* sp. Kajian ini menunjukkan bahawa tumbuhan refugia *T. erecta* dan *Zinnia* sp. adalah serangga yang berpotensi sebagai tumbuhan refugia untuk mengawal pengorek batang padi.

Kata kunci: Kejuruteraan agro-ekosistem; tanaman padi; tumbuhan refugia; pengorek batang padi; parasitoid

INTRODUCTION

Rice is a key staple for food security and the economy in Indonesia and much of Asia, providing over 20% of daily calories globally and up to 76% in Southeast Asia. In Indonesia, per capita consumption averages 124 kg annually, making it the third-largest rice consumer worldwide. Despite significant production, domestic supply often falls short, requiring imports (Mohidem et al. 2022; Purnama et al. 2024). Rice stem borer *Scirpophaga incertulas* (Lepidoptera, Pyralidae) is a major pest of rice (*Oryza sativa*). The pest can occur during the nursery, vegetative, generative phases, and before harvest. In the vegetative phase of rice plants, the larvae cut the middle of the tillers causing the shoots to wilt, dry up and eventually die (deadhearts symptoms). Mean-while the borer may cause panicles to appear white and empty (whiteheads symptoms) during the generative phase. Damage can reduce rice yields by 10 to

30% each year and can even cause crop losses (Baehaki 2013). Pallavi et al. (2017) reported that the risk of yield loss was up to 87.66% due to *S. incertulas* attack.

In the 2022/2023 planting season, North Sumatra suffered from 35,287.26 ha of rice stem borer infestation. It was reported that the area of stem borer infestation in North Sumatra in May 2022 was around 89.9 ha, consisting of 79.9 ha of light infestation, 4 ha of medium infestation and 6 ha of heavy infestation. Chemical control is a common method of control by farmers with insecticides active ingredients carbofuran and fipronil (Sianturi 2022). However, over relying on insecticides to control rice stem borers, can lead to several adverse effects, including the development of resistance, harm to non-target organisms, pest resurgence, environmental contamination, health risks, and economic burdens (Aktar et al. 2009; Maneepitak & Cochard 2014).

Integrated Pest Management is an ecosystem management with the approach of utilizing agroecosystem components to ensure that pest populations can be controlled. Biological control of rice stem borers has the potential to be implemented considering that natural enemies in rice agro-ecosystems are quite diverse and can control pest populations below the economic threshold (Rahmawasiah et al. 2022; Sholahuddin et al. 2023). Several parasitoids occur in rice cultivation, including *Stenobracon nicevillei* (Hymenoptera: Braconidae) and egg parasitoids such as *Tetrastichus schoenobii* (Hymenoptera: Eulophidae), *Telenomus rowani* (Hymenoptera: Scelionidae), and *Trichogramma japonicum* (Hymenoptera: Trichogrammatidae). Egg parasitoids are particularly effective in controlling pests before they damage crops and play a crucial role in suppressing the yellow rice stem borer, *Scirpophaga incertulas* (Rauf 2000; Wijaya et al. 2024). Parasitoids of rice stem borers can achieve high parasitism, but results are often inconsistent due to inadequate habitat support. Limited plant diversity and poor environmental conditions can reduce parasitoid effectiveness. Enhancing habitat support through diverse and supportive environments, such as natural refugia, can improve parasitoid performance. Thus, promoting egg parasitoids is a key strategy for preventing borer infestations (Awaluddin et al. 2019; Rauf 2000).

An alternative method for controlling rice stem borers is ecological engineering, which modifies the environment based on ecological principles to support habitat manipulation for arthropod management (Gurr et al. 2004). Biological control using egg parasitoids is effective as they attack pest eggs, preventing larval damage, while being safe for consumers and the environment, avoiding resistance, and sustaining control naturally (Wilyus et al. 2012). Compared to infections pathogen or predators, parasitoids are the primary cause of herbivore mortality (Snyder & Ives 2003). Several studies have revealed a strong relationship between parasitoid assemblage and plant diversity. Planting refugia plants in rice agroecosystems is expected to increase the population of natural enemies such as parasitoids and reduce the rice stem borer attack.

Refugia plants planted in the crop cultivation environment can provide several benefits as a natural enemy conservation practice (Colazza et al. 2023). In agricultural ecosystems, good artificial microhabitats are constructed at the edge or within the field (Muhibah & Leksono 2015). Refugia are plants that can provide shelter, food or other resources for natural enemies such as parasitoids. The presence of refugia plants in an agroecosystem can increase the population of natural enemies because refugia plants provide food for natural enemies in the form of nectar. The scent of refugia plant flowers plays an important role in attracting natural enemies (Colazza et al. 2023). Brotodjojo et al. (2019) reported that population of natural enemies was higher in rice plot with refugia plants than without refugia. This proves that refugia plants can increase the abundance of natural enemies. Selection of the right type of refugia for a particular natural enemy will attract many of these natural enemies as well as increase the fitness of parasitoids and maximize them in controlling the pest population that is attacking (Chen et al. 2020). Muniruddin et al. (2023) repoted that paddy plot cultivated with *Turnera trioniflora* showed a higher abundance and diversity of hymenopteran parasitoids than in the paddy plot without *T. turnera.*

Tagetes erecta and *Zinnia* sp. are types of refugia that are widely used in various agroecosystems. Marigolds (*Tagetes erecta*) of the Asteraceae family have great potential as microhabitats for natural enemies in the field. Beetle of the Coccinellidae family are reported to prefer plants of the Asteraceae family (Allifah et al. 2019; Widiastuti 2000). *Zinnia* sp. not only has striking, colorful flowers, but its flowers also bloom all day long. This attracts many types of insects, both natural enemies and pollinators such as bees, butterflies, and others. Other studies report that *Tagetes erecta* and *Zinnia* sp. are effective in attracting natural enemies of *S. incertulas* in rice paddy fields. Additionally, *Zinnia* sp. is a fast-growing plant that is easy to cultivate. Seeds are readily available, and plant regeneration occurs quickly and continuously (Widhayasa et al. 2023). Hence, it is necessary to study the effect of rice agroecosystem engineering with *Tagetes erecta* and *Zinnia* sp. refugia on rice stem borer attacks and the presence of natural enemies in Serdang Bedagai District, Perbaungan Subdistrict. This study was conducted on two rice varieties, namely Inpari 32 and Ciherang, as farmers in this area generally prefer to plant these varieties. In this study, the effect of rice agroecosystem engineering with *Tagetes erecta* and *Zinnia* sp and rice varieties of Ciherang and Inpari 32 on percentage of clumps infested by rice stem borer and number of egg parasitoid emergence was investigated.

MATERIALS AND METHODS

Study Site and Research Design

The study was conducted on farmers' rice fields with an area of approximately 1000 m^2 in Perbaungan District, Deli Serdang Regency, North Sumatra, during the June to September 2024 planting season. The rice fields used had not been treated with pesticides throughout the study period. The research method used a Split Plots Design with the main plot of Refugia treatment namely R0 (without Refugia), R1 (*Tagetes erecta*), R2 (*Zinnia* sp.) and as subplots are 2 (two) rice varieties namely V1 (Ciherang) and V2 (Inpari 32). There were 4 replications in this study. The plot size as the main plot was 4 x 7m^2. Refugia plants were planted with a border line system on each plot with a planting area (embankment) of 50 cm with a plant spacing of 25 cm. Rice plants were planted with a spacing of 25 x 25 cm. The distance between treatment plots was 1 m and the distance between replicates was 1.5 m. The effect of treatment on the observed variables was analyzed by Analysis of Variance. If there is an effect of treatment on the observed variables, then it was continued with Duncan's mean difference test. Data were processed using the IBM SPSS Statistics Program.

Preparation of refugia plants began one month before tillage for research. Before moving the refugia plants to the rice planting area as a border line, they were maintained in polybags to facilitate planting in the research plot. The refugia were transplanted to the plot embankment in one row 3 days before transplanting rice seeds to the field. Initial NPK fertilization at 7-10 days of rice age, vegetative growth fertilization using Urea at 20-30 days of age, panicle formation fertilization at 40-50 days of age using SP-36 fertilizer, ripening fertilization at 90 days of age using KCl fertilizer. During study, it was no pesticide application.

The size of the observation sample plot in each treatment plot was 75x75 cm, there were 4 sub-plots and each sample plot contained 15 rice clumps. The percentage of clumps infested by rice stem borer was observed from 2 weeks until 11 weeks after planting (WAP). The rice stem borer egg clusters were collected every week from 2 to 6 WAP. Egg clusters in sample clumps were taken by cutting the leaves with eggs and placed in plastic tubes measuring 8 cm high, 4.5 cm in diameter. The egg clusters obtained were kept in the laboratory (29±2°C and 80±10% RH) until the parasitoids emerged. The number of parasitoids that emerged was counted and identified refers to Shepard et al. (1987); Borror et al. (1989) at the Karantina Pertanian Laboratory Jl. Sampul Medan.

Parasitoid Identification

The collected samples were brought to the Karantina Pertanian Laboratory prior to identification. The identification was carried out based on morphological examination following Borror et al. (1989) and Shepard et al. (1987).

Data Analysis

The percentage of clump rice infested by *Scirpophaga incertulas* was normalized using $\sqrt{x} + 0.5$ before analysis and data number of egg parasitoids emerging from rice stem borer eggs was normalized using log x +1 (Gomez & Gomez 1984). Data were analyzed using 2-way ANOVA (refugia and rice varieties as variable factors). If there is an effect of treatments on the observed variables, then Duncan's Multiple Range Test (DMRT) were used to separate the means. Data were processed using the IBM SPSS Statistics Program.

RESULT AND DISCUSSION

Rice Clump Infested by Rice Stem Borer *Scirpophaga incertulas*

The analysis of variance (ANOVA) result showed that refugia plant affected the percentage of clump rice infested by *Scirpophaga incertulas* at 6 WAP observation (F=44.460; df=2,6; $P<0.05$) and at 11 WAP (F=27.387; df=2,6; $P<0.05$). Meanwhile, varieties used did not affect the percentage of clump rice infested at 6 WAP (F=2.601; df=1,9; $P>0.05$) and 11 WAP (F=0.178; df=1,9; $P>0.05$).

Planting refugia *Tagetes erecta* and *Zinnia* sp as agroecosystem engineering in a border line on rice plots can significantly reduce the percentage of rice clumps infested by stem borer both at 6 WAP and at 11 WAP observation. Meanwhile, *T. erecta* and *Zinnia sp* showed rice stem borer infestation was not significantly different at 6 WAP. Observation at 11 WAP, *T. erecta* and *Zinnia* sp. showed a different response on the percentage of infested rice clumps. Ciherang and Inpari 32 varieties showed the similar response to rice stem borer infestation. There was no interaction effect between the refugia type treatment and the rice varieties used. Observation data of response percentage of clump rice infested by rice stem borer are presented at Table 1 (deadhearts symptoms) and Table 2 (whiteheads symptoms).

Table 1. Percentage of clump rice infested by rice stem borer at 2 to 6 WAP (deadhearts symptoms)

Treatments	Clump Rice Infested (%)				
	2 WAP	3 WAP	4 WAP	5 WAP	6 WAP
Refugia					
Control	8.34[a]	10.83[a]	17.5[a]	19.17[a]	22.50[a]
Tagetes erecta	0[b]	0[b]	1.67[b]	4.17[b]	4.17[b]

Zinnia sp	0^{b}	0^{b}	0.84^{b}	1.67^{b}	2.5^{b}
Rice Varieties					
Ciherang	3.33	3.89	6.67	7.22	8.33
Inpari 32	2.22	3.33	6.67	9.44	11.11
Interaction	-	-	-	-	-

Notes: Numbers followed by the same letter indicate that they are no-significantly different at the 5% level according to DMRT.
WAP = Week After Planting

Table 2. Percentage of clump rice infested by rice stem borer at 7 to 11 WAP (whiteheads symptoms)

Treatments	**Clump Rice Infested (%)**				
	7 WAP	**8 WAP**	**9 WAP**	**10 WAP**	**11WAP**
Refugia					
Control	5.83^{a}	10.00^{a}	15.83^{a}	17.5^{a}	19.17^{a}
Tagetes erecta	0.00^{b}	0.00^{b}	0.00^{b}	2.50^{b}	4.17^{b}
Zinnia sp	0.00^{b}	0.00^{b}	0.00^{b}	0.00^{c}	0.00^{c}
Rice Varieties					
Ciherang	2.78	5.00	7.78	8.30	8.89
Inpari 32	0.56	1.67	2.78	5.00	6.67
Interaction	-				-

Notes: Numbers followed by the same letter indicate that they are no-significantly different at the 5% level according to DMRT.
WAP = Week After Planting

The results of this study indicate that refugia can reduce the percentage of rice clumps infested by rice stem borer, both in rice plot planted with refugia *T. erecta* and *Zinnia* sp. This is possible by the presence of natural enemies of rice stem borers in refugia plants which results in a reduction in the percentage of rice clumps infested by rice stem borers. The refugia plant *Zinnia* sp. besides having striking, multicolored flowers, the flowers also always bloom throughout the day, this can attract many types of insects, both natural enemies and pollinator insects such as bees, butterflies and others. Herlinda et al. (2019) reported that *T. erecta* and *Zinnia* sp. in paddy rice plantations were effective in attracting natural enemies of rice stem borer. In addition, *Zinnia* sp. is a fast-growing plant that is easy to plant.

During the vegetative growth period (2 to 6 WAP), *T. erecta* and *Zinnia* sp. significantly reduce the percentage of rice clumps attacked by rice stem borers. Meanwhile, the response of rice varieties Ciherang and Inpari 32 to the percentage of rice clumps attacked by rice stem borers was similar during the vegetative growth period. The percentage level of rice stem borer attack on rice clumps during the vegetative period, 2 to 6 WAP and generative period, 7 to 11 WAP can be seen in Figure 1 and 2.

In Figure 1, it can be seen that from 2 to 6 WAP, rice plots without refugia (as control) showed high rice stem borer attack compared to the others. This occurred in both tested varieties Ciherang and *Zinnia* sp. Meanwhile, when the rice plant plot was combined with refugia, it showed a lower percentage of attack throughout the observation from 2 to 6 WAP (deathearts symptoms). In Figure 2, it can be seen that rice plots without refugia plants showed a higher percentage of infested clumps at 7 to 11 WAP (whiteheads symptoms) compared to rice plots with refugia plants around them. However, in rice plots without refugia, the Inpari

32 variety showed a lower percentage of infested clumps compared to the Ciherang variety. Santoso et al. (2022) reported clump rice infested of Inpari 32 variety showed more resistance (13.96%) against rice stem borer *Scirpophaga incertulas* comparing with Cigeulis (34.13%) and M-400 varieties (89.47%) in environment friendly agriculture. Meanwhile, variety studies of Ciherang in several locations indicate it is classified as susceptible, with an infection rate of 6.4% compared to other varieties with infection rates ranging from 4.1–5.6%, and the potential for higher damage if not controlled (Bahar et al. 2020).

Rice plots surrounded by *T. erecta* and *Zinnia* sp refugia plants showed symptoms of whitehearts after 9 WAP with a range of percentage of infested clumps below 5%. This indicates the presence of fewer rice stem borers in rice plots with *T. erecta* and *Zinnia* sp. This result was similar to the study of Brotodjojo et al. (2019) reported the damage intensity due to stem borer infestation on rice 2 to 6 WAP at Tagetes flower and Sunflower showed significantly less damaged (40.21and 35.63%) comparing to the rice plot without flower/refugia (51.46%). Flower strips as agroecosystem engineering will provide food for adult natural enemies, e.g. parasitoids and also function as shelter for them (Colazza et al. 2023). In additions, Herlinda et al. (2019) reported that *T. erecta* and *Zinnia* sp. in rice paddy fields were effective in attracting natural enemies of rice stem borer. In addition, *Zinnia* sp. is a fast-growing plant that is easy to plant. Seeds are very easy to obtain in the form of seeds and plant regeneration will take place quickly and continuously.

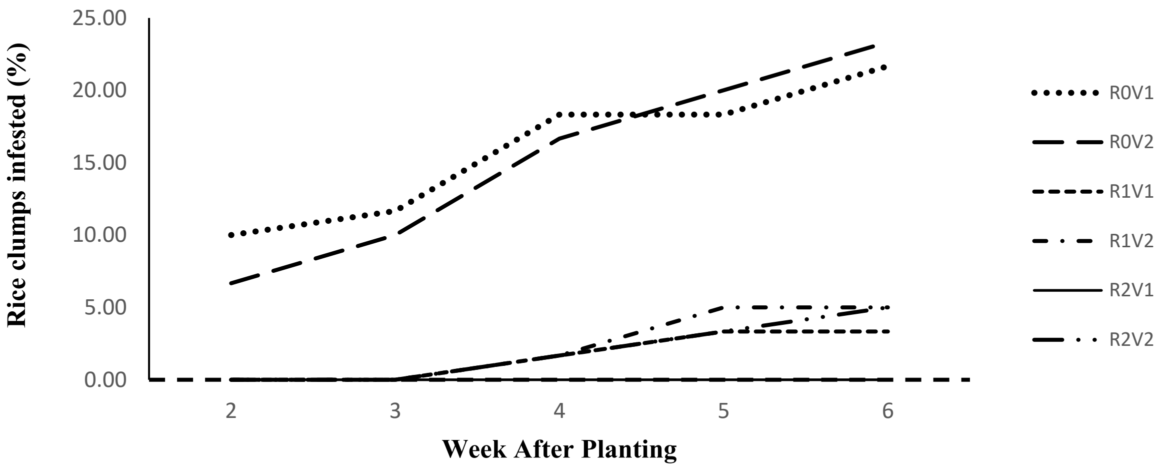

Figure 1. Rice clump infested by rice stem borer 2-6 Week After Planting (deadhearts symptoms)

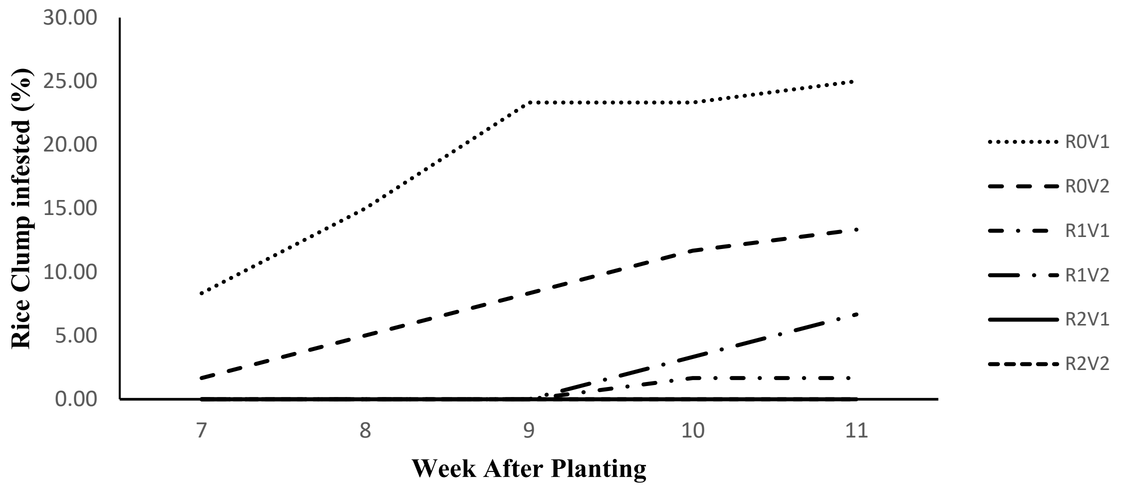

Figure 2. Rice clump infested by rice stem borer 7-11 Week After Planting (whiteheart symptoms)

Parasitoid Emergence from Eggs

The eggs of rice stem borers collected in this study after being stored for some period of time in the laboratory showed the emergence of parasitoids from the eggs. The identification of parasitoids that emerge from the eggs of rice stem borer is *Telenomus* sp. (Figure 3). It was characterized by 5 segmented tarsi, a pointed abdomen and basal abdominal segment with rib-like structures (Shepard et al. 1987).

This proved the presence of rice stem borer egg parasitoids in the study area. Observations on rice stem borer eggs showed that the number of emerging egg parasitoids was significantly higher from stem borer eggs obtained from rice plants surrounded by refugia plants compared to stem borer eggs obtained from rice plants without refugia plants (F = 6.938; df = 2.6; $P<0.05$). However, there was no significant difference in the number of egg parasitoids that emerged from stem borer eggs obtained from Ciherang and Inpari 32 rice varieties (F = 0.226; df = 1.9; $P>0.05$).

Rice stem borer eggs collected from rice plot without refugia (control) showed less emerging egg parasitoids compared to the number of emerging parasitoids from eggs collected from rice plants surrounded by *T. erecta* and *Zinnia* sp. (Table 3). This suggests the possibility that natural enemies as egg parasitoids are more attracted to rice plots planted with refugia around the plot and egg parasitoids can access rice stem borer eggs to lay their eggs.

Zinnia spp. is highly effective in attracting egg parasitoids due to their visually striking flowers, shallow nectar easily consumed by small wasp, making them a valuable component of ecological engineering for rice stem borer management. These refugia has morphological forms and physiological characteristics that can attract insects due to its size, shape, color and smell as well as the content of floral nectar and pollen produced during flowering. The nectar composition includes sugar (glucose, fructose, sucrose) that are useful for increasing adult lifespan, host-searching efficiency, and fecundity. The availability of nectar during the long flowering period (several weeks) supports parasitoids throughout the entire stage when rice plants are vulnerable to stem borer attacks (Gurr et al. 2004; Heong et al. 2021). This helps fulfill the population requirements of natural enemies in an agroecosystem. Planting refugia is also a conservation measure as a food buffer and shelter for natural enemies (Chen et al. 2023; Colazza et al. 2023; Septariani et al. 2019). Refugia plants must have specific characteristics so that natural enemies are interested in finding them. Bright flower colors, nectar and pollen content are special characteristics that are preferred and visited by natural enemies to further become a source of food or shelter (Allifah et al. 2019).

Tagetes erecta (Asteraceae) has great potential as a microhabitat for natural enemies in the field. According to Wardana et al. (2017), marigold flowers *T. erecta* are suitable as refugia plants because the color of the flowers is very striking (bright yellow-orange), highly attractive visually and has a strong smell, so it can attract natural enemies. *Tagetes erecta* produces accessible floral nectar in shallow, disc-shaped composite flower. The nectar easily accessible to short-tongued parasitoids and rich in sugars (mainly sucrose, glucose, and fructose) that increase adult parasitoid longevity, fecundity, flight activity and host-seeking behavior (Dutta & Satpathi 2025).

There was no significant difference between the number of parasitoids that emerged from the eggs of rice stem borers in plots surrounded by *T. erecta* and *Zinnia* sp. refugia, with 37.50 and 43.88 parasitoids, respectively. Likewise, there were similar effect on number of parasitoids emerged from egg rice stem borer clusters collected from Ciherang and Inpari 32 variety. The variety of rice used did not affects the number of parasitoid eggs emerged. Observation data on the number of egg parasitoids that emerged from rice stem borer eggs are presented in Table 3. Herlinda et al. (2019) added that *T. erecta* and *Zinnia* sp. in paddy rice plantations are effective in attracting natural enemies of rice stem borer.

Various elements affect the emergence of adult parasitoids from egg clusters. The overlapping of rice stem borer eggs caused it challenging for parasitoids to search the lower egg masses, leading to a reduction in the number of parasitized eggs. Additional factors include the size of the female parasitoid, the dimensions and quality of the egg host, as well as the egg-laying capabilities of the female parasitoid (Nurafiatin 2000; Jannah 2010). The identification of parasitoids that emerge from the eggs of rice stem borer is *Telenomus* sp. (Figure 3).

Table 3. Number of egg parasitoids emerging from rice stem borer eggs

Treatments	Number of parasitoids
Refugia	
Control	17.88[b]
Tagetes erecta	37.50[a]
Zinnia sp.	43.88[a]
Varieties	
Ciherang	31.58
Inpari 32	34.00
Interaction	-

Notes: Numbers followed by the same letter indicate that they are not significantly different at the 5% level according to DMRT.

Figure 3. Observation of egg parasitoid emergence. a. Plastic tube containing a group of stem borer eggs; b. emerged parasitoid from egg cluster; c. *Telenomus* sp.

CONCLUSSION

It can be concluded that *T. erecta* and *Zinnia* sp. planted as refugia plants in rice cultivations can reduce the percentage of clumps infested by rice stem borers, in both rice varieties. Ciherang and Inpari 32 varieties showed the similar response to the percentage of clumps infested by rice stem borers. The number of parasitoids emerging from egg clusters collected from plots with *T. erecta* and *Zinnia* sp. showed higher numbers. *T. erecta* and *Zinnia* sp. was potentially be used to control rice stem borers. The parasitoid found parasitizing stem borer eggs was *Telenomus* sp.

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AUTHORS DECLARATION

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Conflict of Interest
The authors declare that they have no conflict of interest.

Ethics Declarations
No ethical issue required for this research.

Data Availability Statement
My manuscript has no associated data

Authors' Contributions
Asmanizar conceived this research, Asmanizar and Nurhayati designed the experiments, Satrio Joko Wibowo do the research and collect the samples from the field, Yunita identified the insects (parasitoids), Asmanizar, Nurhayati and Satrio Joko Wibowo participated in the interpretation of the data. All authors read and approved the final Manuscript

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