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Effect of flowering plants on population dynamics of rice stem borers and their natural enemies

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Effect of flowering plants on population dynamics of rice stem borers and their natural enemies

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Abstract. Flowering plants can be used as refugia area for pests' natural enemies. The aim of this research was to study the effect of planting flowering plants in rice field border on the population dynamics of rice stem borers and their natural enemies. The experiment was arranged in a split plot design, with three replicates, the main plots were types of flowering plants i.e., Tagetes (*Tageteserecta L.*), sunflower (*Heliantusannus L.*) and without flowering plants (control); the sub plot were rice varieties i.e., Ciherang and Pandan Putri. Rice were planted in a plot sized 8 x 4 m and the flowering plants were planted along side of the rice plots. The results showed that the population of rice stem borer was significantly higher on control plots than those on plots bordered with flowering plants. Population of natural enemies was significantly lower on rice plots without flowering plants than that on plots bordered with flowering plants. There were significantly more natural enemies in the plots bordered with sunflower than Tagetes. The results indicated that planting sunflowers along the rice field could suppress rice stem borers population and reduced the damage intensity.

1. Introduction

Rice is the main diet for most Asian countries. In Indonesia rice consumption in 2017/2018 was 37.400.000 metric tons, whereas rice production was 37.000.000 metric tons, so Indonesia imported rice for 2.000.000 metric tons [1]. Effort to increase rice production faces many challenges including pests attack. Pest infestation on rice could reduce rice production significantly, and in some cases would lead to crop failure.

Rice stem borers are considered as the key pests for rice. There are five species of stem borers attacking rice in Indonesia, which were *Scirpophagainnotata* (Walker), *Scirpophagaincertulas* (Walker), *Sesamiainferens* (Walker), *Chilosupressalis* (Walker), and *Chiloauricilius* [2]. Stem borers infestations resulted in a condition called "dead heart" when attacking vegetative crop phase and "white head" when attacking crops on reproductive phase. The loss due to stem borer attack could vary depend on the rice variety and severity of the infestation. Yield reduction due to *S. innotata* attack was greater in rice variety Cisadane than in IR64 [3]. Yield loss percentage due to *C. incertulas* infestation on variety BR 31 was 36.26%, whereas on variety Bansphul was 8.77% [4]. During vegetative growth stage infestation until 30% would not cause significant loss for resistant varieties which able to produce many productive tillers [5].

Integrated Pest Management (IPM) is recommended to be implemented to suppress crop loss due to pest attack. This method combines various pest control measures to maintain the pest population under

economic threshold level. Chemical control can be applied when pest population has reached the economic threshold level. Integrated Pest Management is environmentally friendly method as the pest control measure is based on maintaining healthy cropping system that facilitates the natural enemies to regulate pest population. Cultural control, the use of resistant crop varieties and biological control are compatible measures in IPM.

Natural enemies are components of biodiversity on agricultural land which is part of the agroecosystem and interact with other components that make up the agroecosystem. Conservation of natural enemies will have a positive impact on plants cultivation, in controlling pests and other biotic components that eventually increase agricultural production [6, 7, 8, 9, 10]. Considering the important roles of natural enemies in regulating the pest population, therefore conservation and inundation of natural enemies should be done to ensure that population of natural enemies could balance the pest population. To restore the ecosystem's balance due to the pressure of intensive agricultural systems, habitat manipulation needs to be done, for example by providing refugia plants. Refugia plants around the plantation provides several benefits in conservation of natural enemies namely predators, parasitoids and pollinator insects. In agricultural ecosystems, good artificial microhabitat is made on the edge or inside agricultural land [11].

Refugia is an area covered by several types of plants that can provide shelter, food sources or other resources for natural enemies such as predators and parasitoids. Refugia functions as a microhabitat that is expected to be able to conserve natural enemies. Refugia can be flower plants that are intentionally planted and wild plants that live naturally in cropping embankments. These plants are microhabitat for the survival of a particular organisms. Species of refugia planted in rice fields, includes sesame plants (*Sesamum indicum*), sunflowers (*Helianthus annus L.*), tagetes (*Tageteserecta L.*) and Azolla. The presence of sunflowers and tagetes flowers around rice field did not significantly increase population of natural enemies of brown plant hopper [12]. Other study showed that number of natural enemies was higher in the cropping areas with refugia than those without refugia. This showed that refugia plants were able to attract abundance of natural enemies [13]. Based on the description above, this research aimed to study the effect of providing flowers strip as refugia on natural enemies and rice stem borers. In this case refugia plants is expected to increase the abundance of natural enemy populations and thus reduce levels of rice stem borer infestation.

2. Materials and methods

The experiment was arranged in a Split Plot Design, consisted of 6 treatment combinations with 3 replications. Main plots were refugia plants, i.e. sunflowers (*Heliantusannus L.*), tagetes flowers (*Tageteserecta L.)* and without flowers (control) and sub plots were rice varieties (Ciherang and Pandan Putri).

The size of each experimental plot was 8 x 4 m^2. Sunflowers were planted in a strip with distance between plants was 40 cm, while tagetes flowers were planted with a plant spacing of 25 cm. Flowers were planted in one row on the embankment 3 days before transplanting rice seedlings. Rice seedlings were transferred to the trial area at 25 days of age. Planting distance for rice was 25 x 25 cm adjusted to jajarlegowo type 2:1. There was no insecticides application during the study.

The number of rice stem borer eggs and larvae, the number of natural enemies that visited rice, and the level of damage intensity due to rice stem borer attacks were observed weekly from two weeks after planting (wap) until six wap. Observations were conducted on 5 sample plots. The size of each sample plot was 1 m2, containing 16 crops. Rice stem borer eggs and larvae were observed directly on rice, whereas the parasitoids were observed by taking egg clusters and larvae to laboratory for incubation until the emergence of the parasitoids. Predators were observed directly on rice and also by using sweeping net to catch the flying predators. The data were subjected to analysis of variance (ANOVA) followed by Duncan's Multiple Range Test (α: 5%). Percentage data were transformed into arcsin $\sqrt{(x+1)}$ and count data were transformed into $\sqrt{(x+1)}$ to reach normality before analysis.

3. Results and discussion

Rice stem borer moths lay egg in clusters, depending on the species, each cluster approximately consisted of 50-80 eggs [2]. The observation showed that there was no interaction between rice varieties and refugia strip on the number of stem borer eggs cluster. Rice varieties did not significantly affect the number of stem borer eggs cluster. The number of stem borer eggs cluster on rice 2-3 wap was not affected by refugia strip. However, the number of stem borer eggs cluster on rice 4-6 wap was significantly lower on rice with refugia strip, either with tagetes flowers or sunflowers than that without flowers strip (**Table 1**). This result showed that the presence of refugia flower strip could lower the presence of stem borer eggs cluster on rice. This result is similar to the study done by Alifah *et al.* [13].

Table 1. the number of stem borer eggs cluster on rice 2-6 weeks after planting (wap; plot size 1 m^2).

Treatment	Age of rice (weeks after planting)				
	2 wap	3 wap	4 wap	5 wap	6 wap
Rice variety					
Ciherang	0.60	1.07	1.40	1.91	2.49
Pandan Putri	0.53	1.24	1.51	2.31	2.42
Refugia strip					
Tagetes flowers	0.60	1.10	1.23[b]	1.83[b]	2.33[b]
Sunflowers	0.50	1.00	1.10[b]	1.73[b]	2.13[b]
Control	0.60	1.37	2.03[a]	2.77[a]	2.90[a]
Interaction	-	-	-	-	-

[a,b]Means in the same column followed by different letter is significantly different (α=5%).

There was no interaction between rice varieties and refugia strip in affecting the number of stem borer larvae. The number of stem borer larvae was not significantly affected by rice varieties. The number of stem borer larvae on rice 2 wap was not significantly affected by refugia strip. However, the number of stem borer larvae on rice 3-6 wap was significantly lower on rice with refugia strip, either with tagetes flowers or sunflowers compared to control. This pattern followed the dynamic of number of egg population. This result showed that the presence of refugia flower strip could lower the presence of stem borer larvae on rice (**Table 2**). This result is in agreement with the study of Alifah et al. [13].

Table 2. The number of stem borer larvae on rice 2-6 weeks after planting (wap; plot size 1 m^2).

Treatment	Age of rice (weeks after planting)				
	2 wap	3 wap	4 wap	5 wap	6 wap
Rice variety					
Ciherang	0.29	1.07	1.42	1.78	2.09
Pandan Putri	0.31	1.16	1.58	1.89	2.22
Refugia strip					
Tagetes flowers	0.37	1.03[b]	1.37[b]	1.73[b]	2.07[b]
Sunflowers	0.23	0.87[c]	1.30[b]	1.60[b]	1.83[b]
Without flowers	0.30	1.43[a]	1.83[a]	2.17[a]	2.57[a]
Interaction	-	-	-	-	-

[a,b,c]Means in the same column followed by different letter is significantly different (α=5%).

It was shown that there was no interaction between rice varieties and refugia strip in affecting the damage intensity due to stem borer infestation. The damage intensity was not significantly affected by rice varieties. The damage intensity due to stem borer infestation on rice 2 wap was not significantly affected by refugia strips. However, the damage intensity due to stem borer infestation on rice 3-6 wap was significantly lower on rice with refugia strip, either with tagetes flowers or sunflowers than that without flowers strip. This pattern followed the dynamic of stem borer population. This result showed that the presence of refugia flower strip could lower the damage intensity due to stem borer infestation on rice. The effect of sunflowers strip in lowering the damage intensity was significantly stronger than that of tagetes flower (**Table 3**). This could be because sunflowers attracted more natural enemies (**Table 4**), as it was also shown by the study of Alifah et al. [13]. The size of sunflowers is bigger than tagetes flowers, so it will produce more nectar as food of adult natural enemies. Previous studies showed that the presence of floral foods increased longevity and fecundity of many adult hymenopteran, in addition, such feeding is essential for egg maturation of some parasitoids [14, 15, 16]. Furthermore, other studies indicated that incorporating different flowering plants within crops have the potential and practicality to support IPM [6,7, 8, 9]. However, other studies did not find obvious benefits from providing flowering plants in cropping system [10, 11].

Table 3. Damage intensity due to stem borer infestation on rice (%) 2-6 weeks after planting (wap) (plot size 1 m^2).

Treatment	Age of rice (Weeks after planting)				
	2 wap	3 wap	4 wap	5 wap	6 wap
Rice variety					
Ciherang	1.81	8.33	16.94	27.50	40.42
Pandan Putri	1.94	8.89	18.89	30.43	44.45
Refugia strip					
Tagetes flowers	2.29	8,54^{ab}	16.88^{b}	27.17^{b}	40.21^{b}
Sunflowers	1.46	6.46^{b}	14.58^{c}	24.17^{c}	35.63^{c}
Without flowers	1.88	10.83^{a}	21.83^{a}	35.42^{a}	51.46^{a}
Interaction	-	-	-	-	-

^{a,b,c}Means in the same column followed by different letter is significantly different (α=5%).

The observation showed that there was no interaction between rice varieties and refugia strip in affecting the number of natural enemies visiting rice. The number of natural enemies visiting rice was not significantly affected by rice varieties. The number of natural enemies visiting rice 2 wap was not significantly affected by refugia strip. However, the number of natural enemies visiting rice 3-6 wap was significantly higher on rice with refugia strip, either with tagetes flowers or sunflowers than that without flowers strip. This pattern followed the dynamic of stem borer population. This result showed that the presence of refugia flower strip could increase number of natural enemies visiting rice. The effect of sunflowers strip in increasing the number of natural enemies visiting rice was significantly higher than that of tagetes flower (**Table 4**). This result is similar to the study of Alifah et al. [13], but different from the study of Hermanto et al. [12]. Flower strips will provide food for adult natural enemies, e.g. parasitoids [6] and hover flies [19] and also function as shelter for them.

Table 4. Average number of natural enemies visiting rice 2-6 weeks after planting (wap) (plot size 1 m^2).

Treatment	Age of rice (weeks after planting)				
	2 wap	3 wap	4 wap	5 wap	6 wap
Rice variety					
Ciherang	2.16	2.51	3.58	5.60	5.60
Pandan Putri	2.24	2.67	3.27	5.64	5.76
Refugia strip					
Tagetes flowers	2.27	2.60[ab]	3.23[b]	5.17[b]	5.30[b]
Sunflowers	2.23	3.07[a]	4.60[a]	7.60[a]	7.33[a]
Without flowers	2.10	2.10[b]	2.43[c]	4.10[b]	4.40[b]
Interaction	-	-	-	-	-

[a,b,c]Means in the same column followed by different letter is significantly different (α=5%).

There were 14 species of natural enemies found in both rice varieties (Ciherang and Pandan Putri) with tagetes flowers strip and in rice variety Ciherang without flowers strip (**Figure 1, 2, 5**); and 15 species of natural enemies were found in both rice varieties (Ciherang and Pandan Putri) with sunflowers strip and in rice variety Pandan Putri without flowers strip (**Figure 3, 4, 6**). The natural enemies consisted of five parasitoid species (*Cardiochiles sp., Stenobraconnicevelli, Giniozus sp., Itoplectisnarangae,* and *Xanthopimplaflavolineata*) and ten predator species. The most common predator found in rice were *Ophionea sp., Menochilus sp., Oxyopesjavanus., Argiope catelunata.,* and *Micraspis sp.* (**Figure 1-6**). This result implies that sunflowers attract more natural enemies than tagetes flowers. It is suggested that in selecting plant species for flowers strips attractive flower species is preferable than accessible nectar [20]. Providing mixed flowers strip will attract predators and parasitoids that consequently may utilize nectar from less attractive plant species. In the early observation dates, there were fewer natural enemies found and as the rice grew the number of species increased (**Figures 1-6**). Therefore, habitat manipulation by planting flowering plants should be done earlier, this will support the ecosystems to process such as pest control to be more effective with the presence of more species. Many species of natural enemies that live and congregate at the beginning of the season can suppress pest explosion in the early season [12].

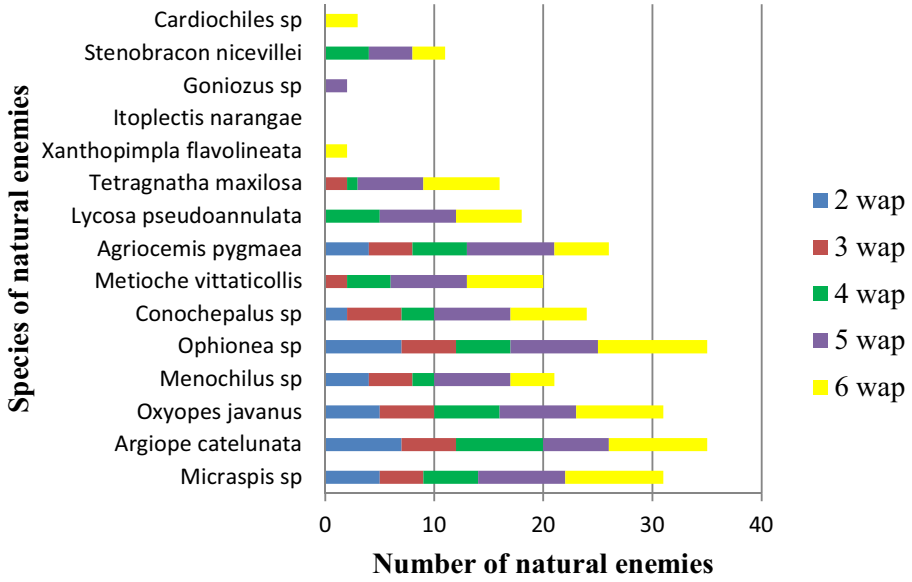

Figure 1. Number of natural enemies in Ciherang with Tagetes flowers strip

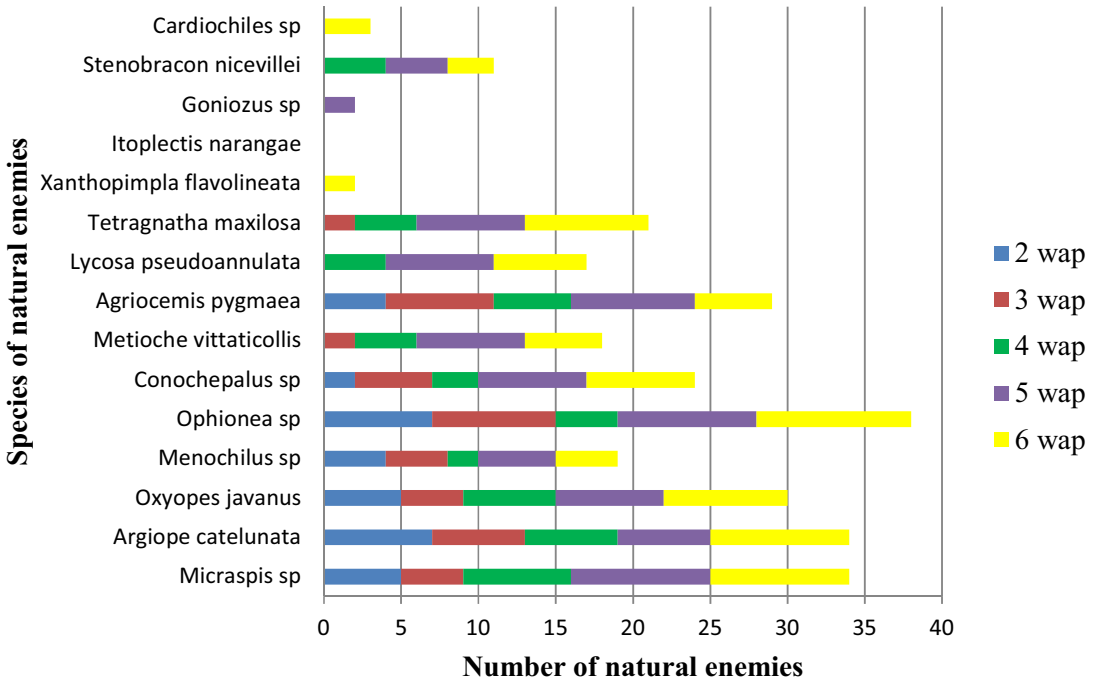

Figure 2. Number of natural enemies in Pandan Putri with Tagetes flowers strip

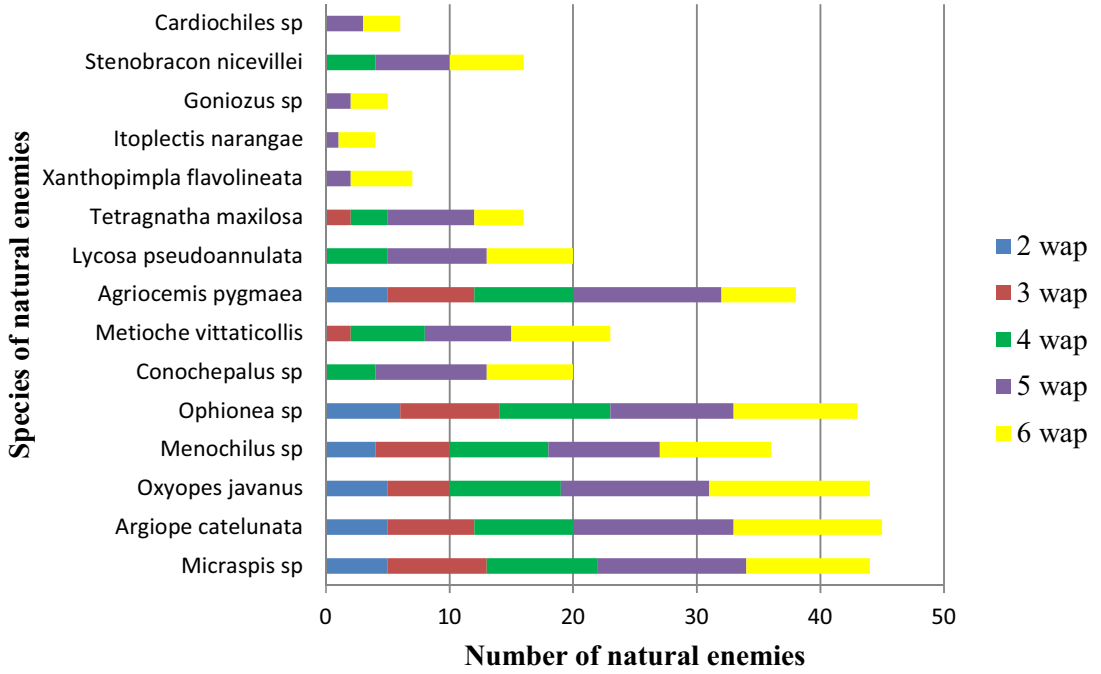

Figure 3. Number of natural enemies in Ciherang with sunflowers strip

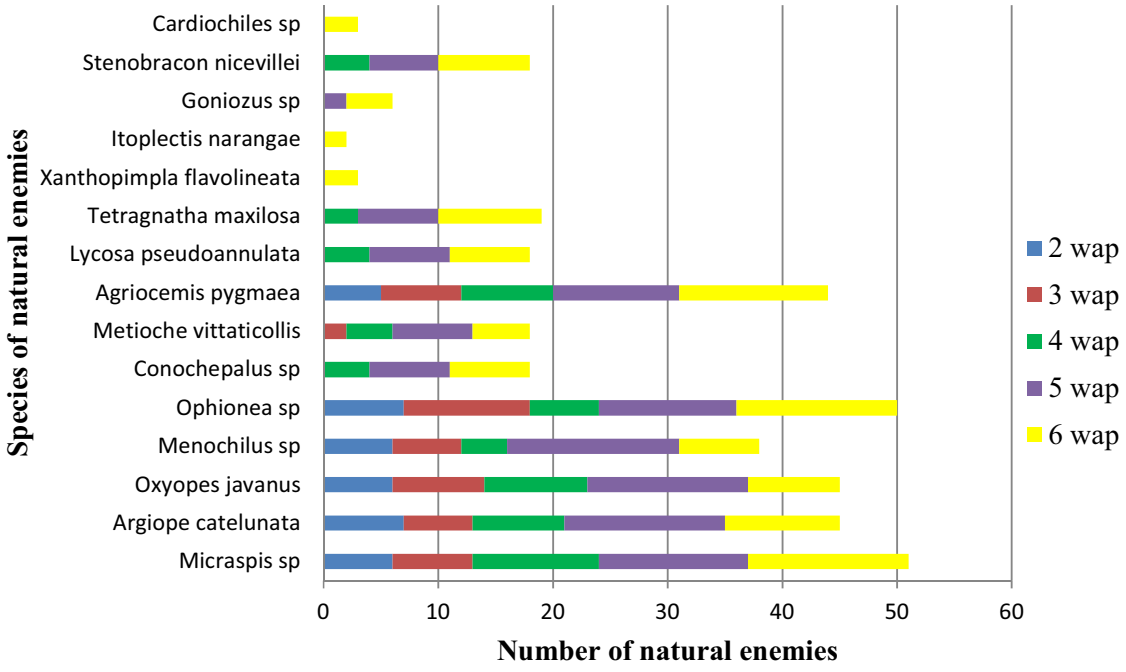

Figure 4. Number of natural enemies in Pandan Putri with sunflowers strip

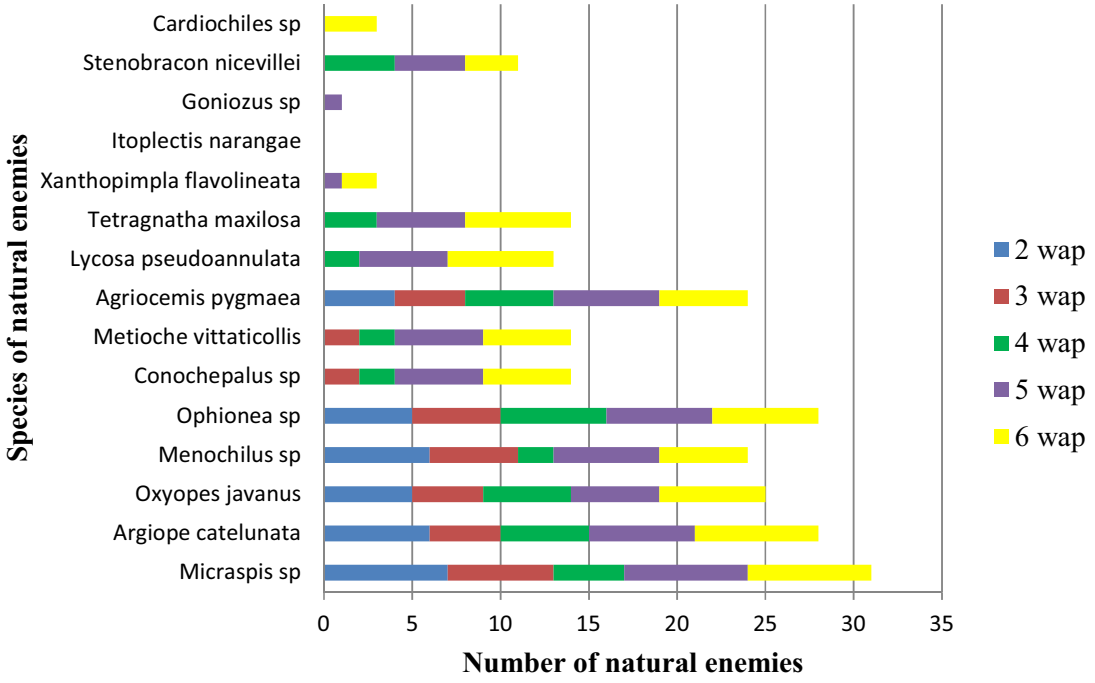

Figure 5. Number of natural enemies in Ciherang without flowers strip

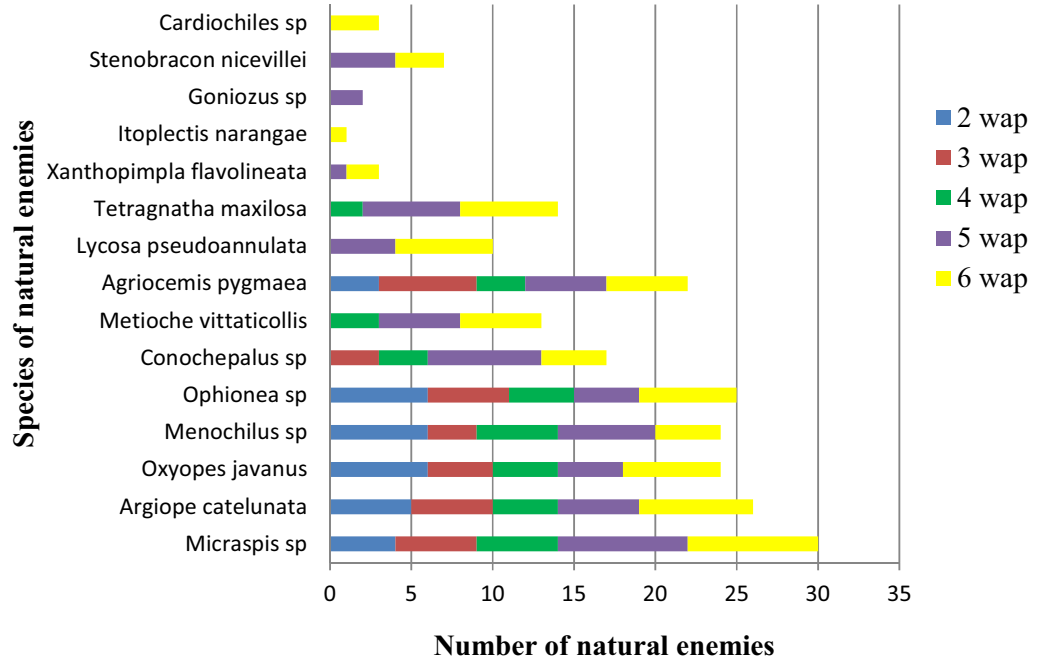

Figure 6. Number of natural enemies in Pandan Putri without flowers strip

4. Conclusion

Population of rice stem borer was significantly lower in rice plots with flowers strip than that in plots without flowers strip. Population of natural enemies was significantly higher in rice plots with flowers strip than that without flowers strip. Sunflowers attracted significantly more natural enemies than tagetes flowers. These results indicated that planting sunflowers in the embankment of rice field could reduce rice stem borers population and lower the damage intensity.

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