**Insect Population in Rice Ecosystems with Various Types of Irrigation and Local Rice Varieties**

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**Abstract.** System of Rice Intensification (SRI) is a new method of cultivation that has been widely done to improve the efficiency of water use, which can affect pest and predator populations. The research aims to determine the types of pests and natural enemies as predators in various irrigations and local varieties of rice. The study was conducted at the Research Field and Laboratory of Protection of the Faculty of Agriculture, University of Muhammadiyah Yogyakarta. The research was carried out with a 3x4 Strip Plot Design in a Completely Randomized Block Design with 3 replications. The factor I was the type of irrigation, consisting of 3 types of treatment, namely conventional irrigation, SRI intermittent irrigation for 10 days inundated 5 days dried, and irrigation for 7 days inundated, 3 days dry. Factor II was rice variety, which consists of 4 varieties, namely Rojolele Genjah, Mentik Wangi, Pandan Wangi, and Ciherang. Observation of pests and predators was done once a week for 5 weeks using the Sweeping Net trap. The numbers of pests and predators were analyzed by Generalized Linear Model analysis. The difference in the mean was further tested by the Tukey test. The results showed that the method of irrigation and varieties gave different effects depending on the role of the insect. Types of irrigation do not affect the population of pests, but irrigation affects the predator population. Varieties affect pest populations and predators. Irrigation types and varieties interact in determining pest populations and predators.

**Key words:** irrigation methods, rice varieties, pests, predator, natural enemies, System of Rice Intensification.

1. **Introduction**

Rice (*Oryza sativa* L.) is the main food crop commodity in Indonesia because most of the Indonesian population consumes rice as a staple food. The demand for rice will continue to increase in line with the increasing population in Indonesia and the world, and changes in the pattern of staple foods in certain areas. In 2019, Indonesia's population reached 268 million with a growth rate of 1.31% [1]. This is a serious threat to Indonesia, so it is necessary to increase food production to meet the food needs of the Indonesian people. The need for rice consumption will continue to increase, therefore the government always strives to increase domestic production. Paddy production in 2019 was 54.60 million tonnes of milled dry unhusked paddy or a decrease of 4.60 million ton (8.42%) compared to 2018. The decrease in paddy production was due to a decrease in the harvested area of 0.7 million ha (6.15%) and a decrease in productivity of 8.9 quintal/ha (1.71%) [1]. Based on 54.60 million ton paddy production Badan Pusat Statistika data 2019, rice production in Indonesia 2019 was 31.31 million ton (57.34%).
One of the cultivation technologies that can help to increase rice productivity is the SRI (System of Rice Intensification) method. The SRI method is an intensive, efficient, and environmentally friendly method of cultivating rice plants. The cultivation of the SRI system of rice plants is carried out with a root system process that is based on soil, plant, and water management so that it does not damage the environment. The SRI system uses field capacity and dry irrigation techniques during the vegetative phase so that it is not continuously inundated like conventional techniques. The use of wide spacing and more use of organic fertilizers. In the cultivation of the SRI system, it has advantages compared to conventional cultivation, including saving the use of seeds, conserving water clothes, increasing the number of tillers, shortening harvest life, and increasing productivity.

Rice plants are ideal hosts for a large number of pests of stem borer insects, grain feeders, root feeders, and leaf feeders [2]. The diversity of insects in different places. Low diversity is found in communities with extreme environmental conditions, for example, dry areas and high mountains, while high diversity is found in areas with optimum environmental conditions, one example of the optimal environment is fertile and mountainous areas. Diversity is the number of species that exist at one time in a particular community. The tropics have a higher diversity of organisms than sub-tropical regions. This is because the tropics have a wealth of species and even higher distribution [3]. To increase rice productivity, there are still obstacles, including the presence of pests. The main pests that attack rice plants include the brown planthopper and rice stem borer. Other pests that have the potential to damage rice crops are green leafhoppers, smelly insects, white leafhoppers, and army worms [4]. The average loss of agricultural production due to pest attack is ± 30% of the potential yield, and 20-25% loss of yield due to pest attack. The application of organic fertilizers with water-saving irrigation techniques does not affect the abundance of herbivores but can decrease the abundance of carnivores [5].

Insect groups based on their diversity of functions in lowland rice agroecosystem include insect pests, natural enemies, and neutral insects such as pollinators. The biotic component that controls the population of insect pests in the agroecosystems is a natural enemy. Natural enemies of wetland rice agroecosystems that include predators and parasitoids include Arthropods [6]. Rove beetles (*Paederus fuscipes*), many predators in the rice ecosystem, often prey on some pests of rice insects such as planthoppers [7]. It has been reported for the first time that *Trigonotylus temis* Reuter caused damage to rice fields in Portugesa and Guárico countries, Venezuela [8]. A simple way to carry out the conservation of natural enemy diversity can naturally improve natural control and prevent pest exploitation [9]. The population dynamics of brown planthoppers (BPH) and natural enemies are influenced by plant season conditions and pest density. Natural control of pests by predators and the degree of pest attack on the ground can be carried out by planting with resistant varieties [10]. An important predatory natural enemy of planthoppers and leafhopper eggs in rice fields in Asia is *Cyrtorhinus lividipennis* Reuter (Hemiptera: Miridae) [11]. The results showed that *C. lividipennis* is a more effective predator in rice crop experiments [12].

The diversity of insect species has a very important impact on stability in the lowland rice ecosystem. The diversity index can be used to express the relationship of species abundance in a community. Insect biodiversity affects the quantity and quality of products produced. Natural ecosystems, generally, occur population stability between pests and natural enemies so that the presence of insect pests can be controlled naturally [13-14]. So far, several studies on insect diversity in rice fields have been carried out. However, research that examines how the effect of the Rice Intensification System on the diversity and population of insects in it has not been widely conducted. This study aims to study the effect of irrigation, rice varieties and the interaction of both factors on the population of pests and natural enemies as predators in SRI rice fields.

### 2. Materials and Methods

The research was conducted at the Research Area and Laboratory of Protection, Faculty of Agriculture, Muhammadiyah University of Yogyakarta. This study used an experimental research method carried out in the field with a 3x4 Factorial Strip Plot research design arranged in a Completely Randomized Block Design method with 3 replications. The factor I Type of irrigation consists of 3 treatments, namely: irrigation with continuous inundation (conventional), irrigation 10 days
intermittent SRI flooded 5 days dry, and irrigation 7 days intermittent flooded 3 days dried. Factor II: Rice varieties consisted of 4 treatments, namely: Rojolele Genjah, Mentik Wangi, Pandan Wangi, and Ciherang.

Research observations included counting the insect population and identifying insects. A sampling of insect pests and natural enemies as predators was carried out from the vegetative phase to the generative phase. The collection of samples of insect pests and predators is carried out using a sweeping net. Insect pests were collected at 6-10 AM. Insect sampling was carried out by swinging the net around the canopy of the rice plants 10 times in a zigzag manner. The insects that have been caught are then cleaned of dirt and stored in insect bottles that already contain 70% alcohol solution, then taken to the laboratory for identification.

Insect identification is carried out to determine the types of insects obtained, by observing morphological characters using a microscope. Identification of insects is carried out according to [15-16]. The insects that have been obtained are then classified to the species level. The insect data obtained were grouped based on their role as pests or predators. The population of pests and predators was analyzed using the Generalized Linear Model with an observation time of 5 weeks. To determine the mean difference between treatments, a further test was carried out using the Tukey (Honestly Significant Difference) test at the alpha level of 5%. The types of insects were analyzed descriptively.

3. Results and Discussion

3.1 Pest Populations

The results showed that the insect populations varied based on their roles. The results of variance showed that there was a significant interaction between irrigation methods and rice varieties on the population of pests and natural enemies (predators), meaning that there was a significant relationship between irrigation methods and varieties on the population of pests and natural enemies (predators). There is no significant interaction between irrigation methods and varieties to the natural enemies (parasitoids).

In rice plants aged 3 WAT, the population of insect pests with SRI 10: 5 irrigation treatment of Ciherang variety (A2V4) was 11.33 individuals, which is significantly less than the Pandan Wangi variety (A2V3), reaching 23.00 individuals. In rice plants aged 5 WAT, the population of insect pests with SRI 10: 5 irrigation treatment of Rojolele Genjah variety (A2V1) was 19.33, significantly less than the Ciherang variety (A2V4), which reached 27.00 individuals (Table 1). In rice plants aged 1, 2, and 4 WAP, insect pest populations between rice varieties were not significantly different, as did between types of irrigation.

In rice plants aged 3 and 5 WAP, the population of insect pests between rice varieties in conventional irrigation and 7: 3 intermittent irrigation was not significantly different. The development of insect pest populations between rice varieties and types of irrigation in rice plants aged 1, 2, 3, 4, and 5 WAP is presented in Figure 1. The population of insect pests has increased from 1 to 5 WAT of plant age in various irrigation treatments and rice varieties, except for SRI 10: 5 irrigation treatment of Rojolele Genjah (A2V1) varieties and Mentikwangi varieties (A2V2), and Pandanwangi with irrigation 7 wet day and 3 dry days (A3V3) that experienced a decrease in insect pest populations at week 2 than to week 1. The combination of A3V3 treatment also decreased the insect pest population at week 4 compared to week 3. The conventional irrigation treatment of the Mentikwangi variety (A1V2), and the conventional irrigation treatment of the Pandanwangi variety (A1V3) experienced a decrease in insect pest populations at week 5 compared to week 4 (Figure 1).

The population of insect pests in the intermittent irrigation treatment of 10: 5 varieties of Mentik Wangi and Rojolele Genjah fluctuated from the age of 1 to 5 MST of rice plants, but in 10: 5 intermittent irrigation treatment, the varieties of Pandan Wangi and Ciherang at the age of 1 to 5 MST of rice always experienced an increase in the insect pest population. In the 7: 3 intermittent irrigation treatment, there was always an increase in the population of insect pests in the rice varieties Rojolele Genjah, Mentik Wangi, and Ciherang. This shows that as rice plants age, the population of insect pests increases. The population of Pandan Wangi rice insect pests has fluctuated.
| Treatment | Sampling / Plant Age |
|-----------|----------------------|
| A1V1      | 10.67 ± 1.154 mn 13.33 ± 2.08 ghijklmn 15.33 ± 1.154 efgijklmn 19.67 ± 3.780 abcdedefg 23.00 ± 1.000 abcd |
| A1V2      | 11.00 ± 1.000 lmn 13.00 ± 3.605 hijklmn 15.33 ± 2.516 efgijklmn 23.00 ± 2.000 abcd 21.00 ± 1.000 abedef |
| A1V3      | 12.00 ± 1.000 jklmn 13.67 ± 1.154 fghijklmn 19.67 ± 1.154 abcdedefghi 23.00 ± 1.732 abcd 20.67 ± 5.507 abedefg |
| A1V4      | 11.33 ± 0.577 lmn 12.67 ± 0.577 hijklmn 17.33 ± 0.577 cdefghijklmn 21.33 ± 1.154 abcd 26.00 ± 1.732 ab |
| A2V1      | 12.33 ± 0.577 ijklmn 11.67 ± 1.527 klmn 16.33 ± 1.154 defghijklmn 18.33 ± 3.214 cdefghijkl 19.33 ± 4.725 bcdefghij |
| A2V2      | 11.33 ± 0.577 lmn 9.00 ± 0.000 n 17.00 ± 0.000 defghijklmn 19.67 ± 4.932 abcdedefghi 21.67 ± 1.527 abcede |
| A2V3      | 9.00 ± 1.732 n 13.00 ± 2.645 hijklmn 20.00 ± 1.000 abcdedefghi 20.67 ± 1.527 abcdedefg 23.33 ± 0.577 abcd |
| A2V4      | 11.67 ± 0.577 klmn 12.00 ± 3.464 jklmn 11.33 ± 1.527 lmn 19.00 ± 3.605 bcdefghijk 27.00 ± 3.605 a |
| A3V1      | 10.67 ± 1.154 mn 11.00 ± 2.645 lmn 16.00 ± 2.645 defghijklmn 20.67 ± 1.527 abcdedefg 22.67 ± 1.154 abcd |
| A3V2      | 11.33 ± 0.577 lmn 11.33 ± 1.154 lmn 18.00 ± 3.464 cdefghijklmn 21.67 ± 0.577 abcdedefg 22.00 ± 1.732 abede |
| A3V3      | 12.67 ± 0.577 hijklmn 12.33 ± 1.154 ijklmn 17.67 ± 2.516 cdefghijklmn 16.33 ± 4.932 defghijklmn 23.00 ± 1.000 abcd |
| A3V4      | 12.33 ± 0.577 ijklmn 13.33 ± 1.527 ghijklmn 21.00 ± 1.000 abcdedefghi 21.33 ± 0.577 abcdedefg 24.67 ± 1.154 abc |

Note: The mean value of treatment followed by the same letter in one column and row is not significantly different based on the Tukey test with a level of α = 5%. A1 = conventional irrigation, A2 = SRI irrigation 10 days flooded 5 dry days, A3 = SRI irrigation 7 days flooded 3 dry days, V1 = Rojolele Genjah, V2 = Mentikwangi, V3 = Pandanwangi, V4 = Ciherang.
Note: A1 = conventional irrigation, A2 = SRI irrigation 10 days inundated 5 dry days, A3 = SRI irrigation 7 days flooded 3 dry days, V1 = Rojolele quickly, V2 = Mentikwangi, V3 = Pandanwangi, V4 = Ciherang.

Figure 1. Pest population based on the age development of rice plants.

Pests found during the study consisted of the orders Diptera (Tephritidae), Hemiptera (Cicadellidae and Coreidae), Lepidoptera (Crambidae), and Orthoptera (Acrididae, Gryllidae, and Pyrgomorphidae). Insect pests that attack rice plants are identified based on family abundance. The insect pests that mostly attack rice plants are the leafhoppers of the Hemiptera order, the Cicadellidae family of the Cicadella sp. (Figure 2). The leafhopper pest is a rice plant pest that causes the most losses to farmers in Indonesia. These tiny insect pests suck the juices of rice plants and spread a virus (reovirus) that causes rice plants to become infected. Planthopper pests develop in rice plants when they form tillers starting from long-winged leafhoppers that move from one place to another. Usually, planthoppers attack rice in the young parts of the plant. The planthopper has a mouthpiece in the shape of a stylet to suck plant fluids so that it prefers young plant parts.

The highest abundance of the family Cicadellidae was found in the 7:3 intermittent irrigation of the Mentik Wangi variety (A3V2). The lowest abundance of insect pests in the family Cicadellidae was found in 10:5 intermittent irrigation of the Mentik Wangi variety (A2V2). The abundance of the family Cicadellidae in 10:5 intermittent irrigation (A2) is lower than that of 7:3 intermittent irrigation (A3). This shows that 10:5 intermittent irrigation (A2) is more effective in reducing the intensity of the planthopper population that attacks rice plants because the land conditions with 10:5 intermittent irrigation treatment have humid conditions. Intermittent watering with field capacity land conditions can help the growth of good rice plants and can prevent high attacks of leafhoppers [17].

Insect pests of the order Lepidoptera family Crambidae and order Diptera Family Tephritidae have a lower abundance than the order Hemiptera family Cicadellidae. The abundance of insect pests of the order Hemiptera (Coreidae) and Orthoptera (Acrididae, Gryllidae, and Pyrgomorphidae) was lower, lower than that of the order Lepidoptera family Crambidae and the order Diptera Family Tephritidae. The results revealed that 15 loci were hypervariable and showed polymorphism among different biotypes of this pest. This marker proves to be used as a useful tool for strategizing for the study of evolution and integrated pest management in biotypes in this main pest of rice [18].

3.2 Populations of Predator

In rice plants aged 1 WAT, the predatory population of 7 wet day:3 dry days intermittent irrigation treatment of Ciherang (A3V4) variety was 20.33 individuals, significantly more than Pandan Wangi (A3V3) and Mentikwangi (A3V2) variety, respectively 9.00 and 6.67 individuals (Table 2). In conventional and intermittent irrigation treatment, SRI 10:5, the predator population between rice varieties was not significantly different. In rice plants aged 2, 3, 4, and 5 WAP, the
The predator population between rice varieties were not significantly different, as well as between types of irrigation was not significantly different. The development of predatory populations between rice varieties and types of irrigation for rice plants aged 1, 2, 3, 4, and 5 WAP is presented in Figure 3.

Figure 2. Abundance of population based on pest family.

Figure 3. Predatory populations at various treatments and ages of rice plants.
Table 2. Effect of varieties and irrigation methods on population of predator based on the development of rice plants

| Treatments | 1 | 2 | 3 | 4 | 5 |
|------------|---|---|---|---|---|
| A1V1       | 8.00 ± 1.000 jklm | 14.67 ± 2.081 cdefghijklm | 19.00 ± 4.358 abcdefghi | 20.67 ± 2.516 abcdefgh | 21.00 ± 3.605 abcdefgh |
| A1V2       | 7.67 ± 3.055 klm | 14.67 ± 4.932 cdefghijklm | 18.67 ± 1.527 abcdefghij | 18.00 ± 1.000 abcdefghijk | 19.67 ± 3.785 abcdefgh |
| A1V3       | 13.67 ± 4.041 defghijklm | 16.67 ± 6.429 abedefghijkl | 21.67 ± 7.571 abedefg | 23.00 ± 1.000 abced | 21.67 ± 4.041 abedefg |
| A1V4       | 10.33 ± 4.041 hijklm | 18.00 ± 1.732 abedefghijk | 19.00 ± 1.000 abcdefgh | 21.33 ± 2.081 abedefg | 25.33 ± 4.041 abc |
| A2V1       | 7.67 ± 2.309 klm | 14.00 ± 1.732 defghijklm | 18.33 ± 3.511 abedefghijk | 18.00 ± 1.000 abcdefghijk | 19.67 ± 3.214 abedefgh |
| A2V2       | 4.67 ± 1.527 m | 12.67 ± 4.041defghijklm | 20.33 ± 2.886 abedefgh | 23.00 ± 1.000 abced | 19.67 ± 3.214 abedefgh |
| A2V3       | 11.00 ± 2.645 ghijklm | 20.00 ± 1.000 abedefghijkl | 24.00 ± 2.000 abced | 21.33 ± 2.081 abedefg | 26.33 ± 2.510 a |
| A2V4       | 11.67 ± 4.725 fghijklm | 17.00 ± 1.732 abedefghijkl | 16.33 ± 2.886 abedefghijkl | 19.00 ± 0.000 abedefghi | 25.00 ± 2.645 abc |
| A3V1       | 11.33 ± 0.577 ghijklm | 19.00 ± 3.000 abedefgh | 20.00 ± 5.291 abedefgh | 21.00 ± 4.582 abedefgh | 18.00 ± 0.000 abedefghijk |
| A3V2       | 6.67 ± 2.309 lm | 23.00 ± 7.549 abcede | 18.67 ± 0.577 abedefghij | 24.00 ± 5.291 abcd | 19.00 ± 3.605 abedefghi |
| A3V3       | 9.00 ± 1.000 ijkmlm | 19.67 ± 6.429 abedefghi | 24.33 ± 3.055 abcd | 19.67 ± 3.214 abedefghi | 25.67 ± 2.510 ab |
| A3V4       | 20.33 ± 3.055 abedefgh | 15.33 ± 3.214 bdefghijklm | 18.67 ± 4.509 abedefghj | 23.67 ± 3.511 abcd | 23.67 ± 4.041 abcd |

Note: The average value of treatment followed by different letters in the same column is significantly different based on the Tukey test with a significant level of 5%. A1 = conventional irrigation, A2 = SRI irrigation 10 days flooded 5 dry days, A3 = SRI irrigation 7 days flooded 3 dry days, V1 = Rojolele Genjah, V2 = Mentikwangi, V3 = Pandanwangi, V4 = Cihareng.
The predator population increased from 1 to 2 WAT of plant age in various irrigation treatments and rice varieties, except for the 7 wet days : 3 dry days intermittent irrigation treatment of Ciherang varieties (A3V4), which decreased the predator population at week 2 compared to week 1. The predatory population increased from 2 to 3 WAP of plant age in various irrigation treatments and rice varieties, except for the 7: 3 intermittent irrigation treatment of Mentik wangi (A3V2) varieties, which experienced a decrease in predator population at week 3 compared to week 2. The predatory population increased from 3 to 4 WAP for various irrigation treatments and rice varieties, except for the conventional irrigation treatment of the Mentik wangi variety (A1V2), which decreased the predator population at week 4 compared to week 3. Predatory populations increased from 1 to 2 WAP of plant age in various irrigation treatments and rice varieties, except for conventional irrigation treatment of Pandanwangi variety (A1V3), 10: 5 intermittent irrigation of Rojolele Genjah (A2V1) and Mentikwangi (A2V2) varieties, and 7 intermittent irrigation : 3 varieties of Rojolele Genjah (A3V1) and Mentik wangi (A3V2) which experienced a decrease in predator population at week 5 compared to week 4. Predatory populations in 7: 3 intermittent irrigation treatment, Mentik fragrant (A3V2) varieties from the age of 1 to 5 WAP of rice plants experienced fluctuations. The population of natural predatory enemies in the intermittent irrigation treatment was 10: 5, Ciherang rice varieties (A2V4) from the age of 1 to 4 WAP of rice plants experienced fluctuations. Predatory populations of 10: 5 intermittent irrigation treatment varieties Rojolele Fast at the age of 1 to 4 MST rice plants always experience an increase in population, as well as 7: 3 intermittent irrigation always increases. This shows that with the increasing age of rice plants from the age of 1 to 4 weeks, the population of Rojolele Rapid predators with 10: 5 and 7: 3 intermittent irrigation increases.

Predators obtained consisted of the Araneae order (Oxyopidae and Tetragnathidae), the Coleoptera order (Carabidae, Chrysomelidae, and Coccinellidae), the Diptera orders (Anthomyiidae, Sciomyzidae, and Drosophilidae), the Hemiptera order (Alydidae and Mesovellidae), and the Odonata order (Coenagrionidae). Coleoptera, Hemiptera, and Odonata are exclusively beneficial as predators although...
at a young stage they may be considered prey [19]. Emamectin benzoate in *P. fuscipes* is an important predator of the brown planthopper *N. lugens* is a compound that has a deadly effect and sublethal [20].

Based on the identification results of the abundance of predators based on the level of family abundance, the predators that were most often found in rice were the Diptera order, Anthomyiidae family, the Anthomyia sp (Figure 4). Anthomyiidae family is a type of fly, namely pirate flies or predatory flies. Anthomyiidae family kills by eating or sucking their prey quickly. This fly preys on other flies, moths, dragonflies, and spiders.

The highest abundance of predators in the Diptera order of the Drosophilidae family was found on land with conventional irrigation treatment with the Rojolele Genjah (A1V1) variety, while the lowest abundance was found inland with 7: 3 intermittent irrigation treatment with the Mentik wangi (A3V2) variety. Predators of the Diptera order that were found were flies and mosquitoes. The Diptera order is more effective at using 7: 3 intermittent irrigation. High natural enemy populations in the food chain are affected by this [21]. The food chain that is formed is longer and some symbioses produce positive feedback and can reduce disturbances in the ecosystem so that a balanced ecosystem is created.

4. Conclusion

Based on the results of the study, it can be concluded that the method of irrigation influences the predator population, but the method of irrigation does not affect the population of insect pests. Rice varieties affect insect pests and predators. Irrigation interacts with varieties against insect pests and predators.

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