Agrobiodiversity of using refugia plants towards several plant gardens at Tulung Rejo, East Java

Muhammad Yusril Hardiansyah¹, Hartini², Yunus Musa¹

¹ Department of Agronomy, Agrotechnology Study Program, Faculty of Agriculture, Hasanuddin University, Makassar, Indonesia
² Office of Food Crop, Horticulture and Plantation of South Sulawesi, Makassar, Indonesia

Email: yusrilhardiansyah1@gmail.com

Abstract. A study and identification on agrobiodiversity of refugia plant as alternative solution by farmers towards their several plant gardens to repel pest was conducted at Tulung Rejo, East Java, Indonesia in March 2021. Refugia plants are biodiversity plants that grow around cultivated plants, which have the potential as a place of protection and a source of food for natural enemy insects (both predators and parasitoids). The principle of refugia plants is that these plants can attract and become a place of life and a source of life for insects, natural enemies of pests. The research was using a survey method with interview with farmers who have a land and using refugia plant as a natural pesticide to repel pests of their plants. Besides, this research was also using a physical identification of several refugia plants. Among several locations in Tulung Rejo, the results show that on average farmers use refugia plants of the type of kenikir flower Cosmos caudatus. This has evident because from 20 garden locations, 18 of them use Cosmos caudatus. The needs of farmers in Tulung Rejo, East Java to repel pests naturally.

1. Introduction

Tulung Rejo Village, Kediri, East Java is one of the villages with a fairly high level of tourism and agriculture majority, every year Tulung Rejo Village becomes one of the most visited areas in Indonesia [1]. Focuses on his daily needs for farming and teaching in various course institutions. The main agriculture in Tulung Rejo is corn, rice, soybeans, sweet potatoes, beans, etc. So it is not surprising that the people there use various methods of farming [2]. One of the most common methods used by farmers in Tulung Rejo Village is to use natural control methods to repel various pests. The use of Refugia plants is one of the main alternatives for farmers. The efficacy of the refugia plant is proven to repel pests in rice naturally. Therefore, the biodiversity of refugia plants in various lands and gardens of farmers is the most desirable thing in Tulung Rejo Village.

Refugia plant agrobiodiversity is a microhabitat planted around cultivated plants for predators and parasitoids to breed. The benefits of refugia as a natural enemy conservation area in rice fields are as a pest trap plant, pest repellant plant, shelter, attracting natural enemies to live and breed in the area because it provides a source of nutrients and energy such as nectar, honey powder and honey dew needed by the enemy. Natural environment so that the presence of natural enemies can balance the pest population at a limit that is not detrimental [3].
Types of plant biodiversity that can be used as refugia plants include flowering plants, ornamental plants, broadleaf weeds, wild plants that are planted or grow alone in the planting area, and vegetables [4]. Refugia plant biodiversity with striking colors is a plant that is easy to cultivate as a place for microhabitat and certain organisms. In agricultural land ecosystems, the existence of a good artificial microhabitat is on the outskirts or embankments of agricultural areas [5]. The existence of microhabitats and various kinds of pests have an impact on the number of arthropods in the rice field ecosystem [6].

Farming techniques such as planting marginal plants can encourage the conservation of natural enemies such as predators [7]. The biodiversity of Refugia plants can increase the chances of natural enemies in controlling pests that interfere with rice plants [8]. Refugia plant is a very good plant and easy to cultivate as a natural enemy microhabitat in plants. Natural enemies really enjoy the diversity of refugia plants because they are beneficial for the microhabitat. A problem-solving concept that can be applied in pest control is to plant plants that are used as refugia so that predator conservation can be maintained [9].

Refugia plants have characteristics; plants have flowers and striking colors, plant regeneration is fast and sustainable, seeds are easy to obtain, easy to plant, and can be planted intercropping with other plants. Flowering plants that are used as refugia plants are expected to be a place of protection as well as a provider of feed for predators from rice plant pests. The food that predators get from flowering plants is honey and nectar from flowers and insect pests that hide in these plants. According to [10], besides being able to get honey and nectar from the flowering plants they visit, predators can also find prey hiding in these flowering plants. Therefore, the presence of refugia plants can be a solution that can repel various pests on the main crop.

This study aims to determine and identify the level of agrobiodiversity and the existence of the use of refugia plants used by farmers in the Tulung Rejo Village area, East Java, Indonesia. This research can be used as a reference for the latest information and a source of insight into the existence of various types of refugia plants in Tulung Rejo Village.

2. Methods
This research was conducted at Desa Tulung Rejo, Kediri District, East Java, Indonesia. This research took place from January to March 2021. The tools used were analytical scales, record tool, ruller, camera and writing instruments. This research was conducted with survey analytical and indentify with physics commodity of plants. The steps for implementing the test are as follows:

2.1. Survey location
The initial stage in this research is to conduct site surveys in several specific locations in Tulung Rejo Village. There are 20 main locations that became the point of conducting the survey. The process of finding the location is by considering the condition of the main plants used by farmers such as (Rice, Corn, Long Beans, Watermelon, Shallots, etc.) so that the refugia plants used by farmers to repel pests depend on the plants they plant. The location that became the main point was on several roads at several location points in Tulung Rejo Village. Of the 20 main location points, including land and gardens along the Beringin Mulyoasari road, Gelagah road, Kemuning road, Pancawarna road, Manggar road, Mayang road, Cambodia road, Seruni road, Flamboyan road, Veteran road, Selasih road, Sakura road, Brawijaya road, Langkat road, Garuda road, cokroaminoto road, Gajahmada road, Yos Sudarso road, Asparaga road, Raflesia road.
2.2. Identify the refugia plant

The process of identifying the biodiversity of the refugia plant is using the physical identification method for the refugia plant. This identification process is by matching the physical appearance of the refugia plant type and then comparing it with the plant species obtained from various sources of identification books and journals that display similar images. The identification process is carried out by looking at the appearance of flowers and the number of plant groups that grow in one point. The number of refugia plant species identified were 11 types of refugia plants including Helianthus annuus, Mirabilis jalapa, Cosmos caudatus, Bougainvillea, Catharanthus roseus, Zinnia peruviana, Zinnia acerosa, Zinnia bicolor, Zinnia grandiflora, Zinnia elegans, Tagetes erecta. Sampling the biodiversity of this refugia plant refers to the opinion of [11].

2.3. Interview

Interviews were conducted with farmers who were in the location, the interview method was divided into 2 types, namely filling out forms and direct interviews. Filling out the form, in this case, the farmers were given a data survey paper consisting of several basic questions on their main commodity crops to detect the use of refugia plants as a natural pest repellent method. Interviews were only conducted to farmers who have gardens or main land that uses the refugia plant. Of the 20 location points, not all farmers use refugia plants as repellents. Therefore, there were 14 farmers who were successfully interviewed.

2.4. Analytical data

The data obtained were then combined and matched with the existing numbers and then averaged to obtain the highest and lowest refugia agro-biodiversity species in each species at several point locations in Tulung Rejo Village, East Java. The formula for calculating the average is as follows:

$$\bar{X} = \frac{\sum f_i x_i}{\sum f_i}$$

Where $\bar{X}$ = Average; $\sum fixi$ = Total sum of all number; and $\sum fi$ = Number of item in the set average.
3. Results and discussion
The following is a table of observations made in this study. Table 1 describes various types of refugia agrobiodiversity at various survey locations.

**Table 1.** The average presentation of type of refugia plants which conducted by several point location at Tulung Rejo, East Java, Indonesia

| No | Location of Observation (Road Name) | Main Plants | Type of Refugia Plants (per group of plant) (%) |
|----|------------------------------------|-------------|---------------------------------------------|
|    |                                    |             | Helianthus annuus | Mirehbalis jalapa | Cosmos caudatus | Bougainvillea | Catharanthus roseus | Zinnia elegans | Zinnia roseus | Zinnia stricta | Tagetes erecta | Total (118.9 %) |
| 1  | Beringin Mulyoasari                | Rice        | 87 | 3 | 78 | 64 | 87 | 0 | 65 | 43 | 8 | 49.9 |
| 2  | Gelagah                            | Corn        | 0  | 2 | 0  | 34 | 23 | 0  | 0  | 4  | 2  | 0  | 5.9  |
| 3  | Kemuning                           | Corn        | 0  | 0 | 17 | 0  | 0  | 3  | 16 | 4  | 2  | 5.0 |
| 4  | Pancawarna                         | Rice        | 0  | 4 | 7  | 13 | 20 | 0  | 0  | 0  | 3  | 0  | 0  | 4.2 |
| 5  | Manggar                            | Rice        | 0  | 0 | 3  | 12 | 0  | 0  | 0  | 0  | 3  | 5  | 4  | 2.5 |
| 6  | Mayang                             | Corn        | 0  | 1 | 0  | 14 | 0  | 0  | 0  | 0  | 14 | 11 | 5  | 5.1 |
| 7  | Kamboja                            | Shallot     | 0  | 0 | 6  | 4  | 7  | 0  | 0  | 0  | 0  | 0  | 1.5 |
| 8  | Seruni                             | Rice        | 0  | 1 | 7  | 0  | 5  | 0  | 2  | 3  | 3  | 0  | 3.2 |
| 9  | Flamboyan                          | Watermelon  | 0  | 0 | 8  | 0  | 4  | 0  | 6  | 0  | 5  | 0  | 2.1 |
| 10 | Veteran                            | Rice        | 0  | 6 | 9  | 15 | 11 | 9  | 0  | 2  | 0  | 0  | 4.7 |
| 11 | Selasih                            | Corn        | 0  | 7 | 7  | 0  | 7  | 0  | 0  | 0  | 4  | 2  | 0  | 2.5 |
| 12 | Sakura                             | Rice        | 0  | 0 | 13 | 13 | 12 | 16 | 2  | 0  | 14 | 5  | 3  | 7.1 |
| 13 | Brawijaya                          | Rice        | 0  | 4 | 6  | 0  | 7  | 0  | 6  | 0  | 3  | 0  | 2.4 |
| 14 | Langkat                            | Rice        | 0  | 3 | 8  | 16 | 5  | 6  | 0  | 0  | 2  | 0  | 0  | 3.6 |
| 15 | Garuda                             | Rice        | 0  | 0 | 9  | 0  | 2  | 4  | 0  | 4  | 0  | 2  | 6  | 2.5 |
| 16 | cokroaminoto                       | Rice        | 2  | 0 | 12 | 0  | 15 | 0  | 2  | 13 | 13 | 5  | 5.6 |
| 17 | Gajahmada                          | Rice        | 0  | 1 | 8  | 4  | 4  | 0  | 4  | 0  | 0  | 0  | 3.5 |
| 18 | Yos Sudarso                        | Rice        | 0  | 7 | 5  | 0  | 1  | 3  | 0  | 0  | 2  | 3  | 0  | 1.9 |
| 19 | Asparaga                           | Rice        | 0  | 0 | 11 | 5  | 0  | 14 | 0  | 0  | 0  | 5  | 0  | 3.2 |
| 20 | Rafflesia                          | Corn        | 0  | 0 | 8  | 0  | 6  | 0  | 0  | 0  | 0  | 0  | 5  | 1.7 |

| Average Total (64.9 %) (%) | 4.45 | 5.45 | 11.1 | 10 | 8.05 | 10 | 0.1 | 1.25 | 7.2 | 5.4 | 1.9 |

Note: The table describes the original data from the physical survey observations on various types of refugia plants that have been averaged.

3.1. The amount of refugia plant
The total number of refugia plants that have been identified is 1298 groups with the majority found in rice commodity plants. There are several types of main plants such as Rice, Corn, Shallot and Watermelon which are planted by farmers, but the most widely used by farmers is rice commodity crops. Overall, among the 20 survey locations in gardens and land, the Cosmos caudatus refugia plant gave the highest number of species with a total of 18 points of survey location. In the opinion of [12],
stated that the refugia plant is one of the natural pest control plants that is quite effective in repelling the main pests in rice. Based on the observations obtained, it can be seen that from the total average number obtained, which is 118%, the most location points that have the biodiversity of refugia plants are Beringin Moyosari Road with the total average number of refugia plants being 49.9% while inversely proportional to the lowest condition. Where the lowest location point that has the biodiversity of refugia plants is Cambodia Road with an average total number of refugia plants is 1.5% plants.

**Figure 2.** The appearance of various agro-biodiversity of refugia plants in Tulung Rejo Village, East Java. The picture was taken on Beringin Moyosari Road

In this case, the plants that are located on the Beringin Moyosari Road are plants that are incorporated in a botanical garden which has become a new tourism place that is often visited by the surrounding community (Figure 2). At Beringin Moyosari Road there were about 549 total groups of refugia plants detected with the highest percentage of 49.9%. This is because the Beringin Moyosari Road around the road is a rice field for farmers and is added to a botanical garden belonging to a farmer who is also domiciled in the area. The majority of the main crops of farmers on Beringin Moyosari Road are rice, along the way farmers grow rice as a commodity. The existence of the refugia plant dominates the area due to the large area of rice land owned by the farmers, so that it becomes the main method of controlling pests in their rice that can maintain the plant ecosystem naturally. In accordance with the opinion [13], refugia plants can support conservation activities in maintaining the balance of agro-ecosystems on agricultural land. The color of the refugia plant is able to attract natural enemies to come and become a micro-habitat for natural enemies. In addition to the attractiveness of the color of the refugia, the availability of nectar content and the condition of the flowers also affect the diversity and abundance of natural enemies [14].

Based on the author's interviews with farmers, refugia plants are very helpful in controlling pests in their rice crops. This is because various types of refugia plants have their own uniqueness and characteristics to emit an aroma that invites various plant pests. In accordance with the opinion of [15], stated that the refugia plant is a flowering plant that is a habitat for insects because it is able to provide the food needed by insects in the form of nectar and honey. The presence of natural enemies can be increased by providing habitat and food sources for their survival, so that the refugia plants around the plantations become alternative habitats for predators and parasitoids. Refugia plants have an ecological role (functional status) consisting of herbivorous insects (54.14%), pollinators (28.72%), and predators (17.13%).

3.2. *The amount of type of refugia plant*

Based on the observations obtained, it can be seen that from the total average number obtained, which is 64.9%, the highest number of refugia plant species from all main location points is *Cosmos caudatus* with the total average number of refugia plant groups *Cosmos caudatus* is 11.1% . Meanwhile, in contrast to the lowest condition, the lowest average number of species from all main location points was *Zinnia acerosa* with the total average number of *Zinnia acerosa* refugia plant groups was 0.1%.
The large number of refugia plants of the *Cosmos caudatus* type is because this species is one of the most effective refugia plants in controlling pests on various main crops such as rice, corn, etc. In addition (Figure 3a), *Cosmos caudatus* is also one of the refugia plants with the most biodiversity on the island of Java, making it easier for farmers to find. One of the most distinctive things possessed by *Cosmos caudatus* is the appearance of very striking flower colors and the presence of nectar making it one of the good natural insect controllers. This is in accordance with the opinion [16]. The striking color of the refugia flower becomes a microhabitat for natural enemies in obtaining additional food in the form of nectar and honey and the color of the refugia can affect the spectrum of insect vision. The same thing was also stated by [17] that refugia flowers of the Marigold type have striking colors and distinctive aromas so that they can attract insects to come. In other conditions, *Zinnia acerosa* is a type of refugia plant that is quite rare in Indonesia (Figure 3b), especially on the island of Java, so that it becomes one of the few refugia plants in Tulung Rejo, East Java.

### 3.3. Type of refugia at tulung rejo

The following are some types of refugia plants found in Tulung Rejo Village, East Java.

Among these three types of refugia plants (Figure 4), *Cosmos caudatus* is the refugia plant with the most species with an average total number of 11.1% and also the most species found in several locations, reaching 18 locations that already have this species. Very much different from the type *Mirabilis jalapa* which reached an average total number of 5.45%, followed by *Helianthus annuus* species with an average total number of 4.45% or a difference of 1%.
Figure 5. (a) the type of Bougainvillea refugia, (b) the type of Catharanthus roseus refugia, and (c) the type of Zinnia peruviana refugia

Among the three types of refugia plants (Figure 5), Bougainvillea and Zinnia peruviana are refugia plants with quite a lot of species with an average total number of both around 10% but still slightly below Cosmos caudatus. Quite different from the type Catharanthus roseus which reaches an average total of 8.05% or less than 2%.

Figure 6. (a) the type of Zinnia acerosa refugia, (b) the type of Zinnia bicolor refugia, and (c) the type of Zinnia grandiflora refugia

Among these three types of refugia plants (Figure 6), Zinnia grandiflora is a refugia plant with quite a lot of species with an average total number of 7.2% and also quite a lot of species found in several locations. Very much different from the Zinnia bicolor type which reached an average total number of 1.25% which was quite low than the average of other species, followed by Zinnia acerosa species with an average total number of only 0.1% or species that occupied the average number. The lowest average is in Tulung Rejo Village, East Java.

Figure 7. (a) the type of Zinnia elegans refugia and (b) the type of Tagetes erecta refugia
Among these two types of refugia plants (Figure 7), *Zinnia elegans* is a refugia plant with quite a lot of species with an average total number of 5.2% and is also a sufficient type of species scattered in several locations. In contrast to the *Tagetes erecta* type which only reached an average total number of 1.9% which occupied an average number which was quite lower than the average of other species.

4. Conclusion
This study shows how abundant refugia agrobiodiversity is in Tulung Rejo Village, Kediri Regency, East Java. Various types of refugia plants that can be found at 11 different locations make the existence of the use of refugia plants by farmers. Most of the farmers use refugia plants as natural pest control to be applied to rice commodities. With a total of 1298 refugia plant groups, the *Cosmos caudatus* refugia plant species provides the highest number of species with a total presence in 18 survey locations. The highest total species biodiversity of plant refugia is *Cosmos caudatus* with an average percentage of 64.9%, while the lowest total species biodiversity of plant refugia is *Zinnia acerosa* with an average percentage of 0.1%. Consequently, the existence of refugia agrobiodiversity is very helpful in controlling pests for farmers in Tulung Rejo Village, East Java.

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