Dynamics of tungro disease and its vector population on intercropping of rice varieties

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Abstract. Tungro is one of the major diseases has ability reduce the yield potential of rice. The disease was caused by *rice tungro baciliform virus* (RTBV) and *rice tungro spherical virus* (RTSV). Both of virus only transmitted by green leafhoppers, *Nephotettix virescens* in a semi-persistent manner. The research purpose is to control tungro disease and its vectors as well as the diversity of natural enemies by applying the intercropping method of several rice plant varieties. The optimum of disease incidence in 11 weeks observation on the variety of Ciherang, Inpari 32, Inpari 36, and IR 64 planted in intercropping was 7.8%, 7.3%, 3.8%, and 6.3%. Whereas, the incidence on these respective variety planted in monoculture was 9.8%, 8.8%, 4.3%, and 8.5%. Then, the optimum of *N. virescens* population per clump on rice variety with intercropping in the same time of observation was 4.8, 2.3, 1.5, and 4, and on variety with monoculture was 6.5, 4.5, 3.3, and 4, respectively. Moreover, the population of insect predators tended to be higher on variety with intercropping than on rice variety with monoculture. These data indicated that rice planted with variety intercropping was related to the reduction of tungro incidence and its vector and also the increase of insect predators. Therefore, the intercropping of variety could used as one of control method against rice pests and diseases.

1. Introduction
Tungro is the one crucial disease in rice, caused by two forms of viruses: *rice tungro baciliform virus* (RTBV) and *rice tungro spherical virus* (RTSV) [1]. The disease is transferred by green leafhoppers (*Nephotettix virescens* Dist.) (Homoptera: Cicadellidae) in a semipersistent manner after acquiring the virus from an infected plant. In the field, the tungro endemic is influenced by several factors such as availability of inoculum sources, varieties and cropping patterns, physical environmental conditions (temperature and rainfall), biology (the presence of natural enemies), cultivation practices, the occurrence of vector species and populations [7-9]. Among these factors, the last is the most important.

Green leafhopper, *N. virescens* is the most dominant rice disease vector and has the highest transmission efficiency [2-4]. This efficiency can reach 81% in endemic areas and around 52% in non-endemic areas [5,6], especially when the insect acquire the virus from young plants [10,11]. The vector population fluctuation affects of tungro disease if the source of virus inoculum is already in the field [12]. The presence 30–40% of the inoculum sources in the rice plant, accompanied by an increase in the vector population, causing a high incidence of tungro [13]. Furthermore, the development of subsequent infestation is determined by the source of the inoculum in the plant and the population density of the first generation vector [14].
Control of tungro disease has been carried out with various efforts. This control include effective, economical and environmental friendly such as using of resistant varieties [4,15], biological control by using natural enemies [16], resistant variety [17] and technical culture such as Legowo system and varieties intercropping [18]. Varieties intercropping plays a role in limiting the vector distribution [19]. In addition, the intercropping would reduce the use of pesticides, increase natural enemies, and obtain high and stable production yields. The research purpose is to apply rice varieties intercropping to control tungro disease. In this research, we observed fluctuation of tungro incidence, insect vector, and insect predator.

2. Material and methods

The research was conducted in Aka-Akae village, Panca Rijang district, Sidenreng Rappang Regency, South Sulawesi from February 2020 to April 2020. This research was designed in completely randomized design with four treatments and each treatment repeated four times. Treatments consisted of rice varieties having different in their resistance to tungro and green leafhoppers: Ciherang, Inpari 32, Inpari 36, and IR 64. The plantation was divided into two blocks, one block was intercropping and other block was monoculture and each block have area of 12 m x 11 m. The intercropping block was devide into four plots where each plot consisting of four sub-plots as replication. Each replication consisting of two rows of crops representing one variety. The monoculture block was divided into 16 plots where four plots represent one variety. The distance between two block was 4 m.

Rice plantation was planted using Legowo 2:1 system. Fertilization was carried out three times The first was seven days after planting using 75 kg of urea, 45 kg of Phonska, and 45 kg KCl. The second was 21 days after planting by 25 kg of urea and 25 kg KCl. The last was 49 days after planting by 25 kg of urea. Plant maintenance was carried out by regulating the availability of water, weeding and without pesticides application.

Observation of disease incidence was carried out by observing clumps of rice plants showing symptom and calculated using formula [20]:

\[ IP = \frac{n(1)+n(3)+n(5)+n(7)+n(9)}{tn} \]

- IP = tungro disease index
- N = plants showing tungro with a specific symptoms score
- tn = the total of plants observed

| Score | Symptoms (%) | Description |
|-------|--------------|-------------|
| 1     | 0            | no symptoms |
| 3     | 1 - 10       | dwarf symptoms without leaf yellowing |
| 5     | 11 – 30      | dwarf symptoms and not yellow |
| 7     | 31 – 50      | dwarf symptoms and not yellow |
| 9     | ≥ 10         | Stunted by stunts and oranges or die |

The existence of green planthopper population and predators was determined by constant observation of the rice plant. The arthropods including, green leafhoppers and predators, were captured using vacuum pump. After the rice clumps are covered by transparent plastic, these arthropods were sucked and collected to identify and count in the laboratory. T-test was used to determine the significant difference of tungro disease, green leafhopper and predator densities between each rice variety in intercropping and monoculture.
3. Results and Discussion
Rice plants infected by tungro viruses present morphological characteristics such as dwarf, orange, low number of clumps, and many empty panicles [21]. Simultaneously, its physiological signs show a decrease in the amount of chlorophyll and hormones, the reduction of photosynthesis rates, and an increase in the respiratory rate followed by the rise in the oxidase enzyme.

In the field, until two weeks after planting, no symptoms of tungro disease was observed both on monoculture and intercropping plots. Symptoms appear such as dwarf plants and lower clumps number compared to the surrounding plants, although the color of the leaves still does not show a change to orange like tungro symptoms. Stunted symptoms and a reduction in rice tillers were seen three until four weeks after planting. The disease incidence increase with increasing age of the rice plants. According to [22], the tungro infestation was determined by several factors such as the available source of inoculum and the degree of planted varieties’ resistance. The high virus source during the vegetative phase of the plant empirically cause high tungro transmission. The tungro incidence progressing from one week until eleven weeks after planting on rice varieties Ciherang, Inpari 32, Inpari 36, and IR 64 was presented in figure 1.

![Figure 1](image-url)

**Figure 1.** The development incidence of tungro disease in rice varieties: Ciherang (a), Inpari 32 (b), Inpari 36 (c) and IR 64 (d) planted with intercropping varieties and monoculture.

Optimum of disease incidence in all varieties was reached at seven days, except for Inpari 32 was reached at eight weeks after planting. In this phase the disease incidence on Ciherang, Inpari 32, Inpari 38 and IR 64 was 7.8%, 7.3%, 3.8%, and 6.3%. While with monoculture was 9.8%, 8.8%, 4.3% and 8.5%, respectively. Therefore, the incidence of disease in monoculture was higher than in intercropping of varieties. The susceptibility variation of rice varieties into tungro disease depend on the number of resistance genes it contains [3,4]. The disease’s level of damage is affected, beside by rice variety, also by virus strain, plant age, single and multiple infection, and growth environment [23]. Intercropping of rice varieties would influence virus infection and growth environment that can reduce the tungro incidence.

Intercropping also affected the dynamics of green leafhoppers (N. virescens) population. Nymph and adult stages of this vector were not present at first week after planting in all varieties with intercropping and monoculture. This condition was normally related to the absence of eggs and nymph on young plant [4]. Therefore there was not migration from other plantations to the nursery. However, their presence began to appear at three weeks after planting where their population was one insect/clumps in intercropping varieties and 2.75 insects/clumps in monoculture. The population of green leafhoppers was still low at the beginning of planting. They were still in the stage of population formation by finding hosts and adjusting to new environments [24]. After finding a suitable food source, the green leafhoppers population start to grow, in the following week increasing their
population. The dynamics of green leafhoppers at one week until eleven weeks after planting on Ciherang (a), Inpari 32 (b), Inpari 36 (c) and IR 64 (d) varieties was shown in figure 2.

Figure 2. The averages population density of green leafhoppers (GLH, *N. virescens*) on rice varieties: Ciherang (a), Inpari 32 (b), Inpari 36 (c) dan IR 64 (d) planted with in intercropping varieties and monoculture.

The optimum green planthopper population was found five weeks after planting. This population on Ciherang, Inpari 32, Inpari 38 and IR 64 varieties in intercropping was 4.8 GLH/clump, 2.3 GLH/clump, 1.5 GLH/clump, and 4 GLH/clump. While in monoculture was 6.5 GLH/clump, 4.5 GLH/clump, 3.3 GLH/clump, and 4.3 GLH/clump, respectively. Therefore, the intercropping of rice varieties reduced the population of green leafhopper population. It is likely that the presence of different varieties in the same area limits the vectors movement, and consequently reducing the tungro incidence.

Figure 3 The development of predators from one week until eleven weeks after planting on Ciherang, Inpari 32, Inpari 36 and IR 64 varieties. By comparing to the monoculture, the total population of predators in eleven weeks in intercropping varieties was higher. Their optimum on each variety was at five weeks, six weeks, six week, and eight weeks, respectively. In intercropping, the total was 36, 35, 40 and 28 predators, while in the monoculture was 34, 26, 21, 30 predators per clumps, respectively. Dominant predators in two culture systems were lady beetle *Menochilus sexmaculatus* (Coleoptera: Coccinellidae) and dragonfly *Agriocnemis pygmaea* (Odonata: Coenagrionidae). The others were round spider *Araneus inustus* (Araneae: Araneidae), sharp-eyed spider *Oxyopes javanus* (Araneae: Oxyopidae) and long-legged spider *Tetragnatha maxillosa* (Araneae: Tetragnathidae) [25-28]. Coccinellids is a common predator insect in upland rainfed rice ecosystem in the third trophic of ecology hierarchy [19, 28]. These predators are effective in controlling green leafhoppers on rice field [29-31].
In general, the predator population fluctuations did not follow the pattern of the green leafhoppers development in each variety. The effectiveness of predators in controlling the green planthopper population measured based on its predatory degree. The ideal life of natural enemies when their activities and population number increase along the prey population. The number of prey eaten by predator showed successful their control of the population and result of predation activities [25]. At four and five weeks after planting, predators presence increased significantly because they were supported by the increase GLH population in nymph and adult stages. Predation will increase when prey is abundant; consequently, predation on certain prey types will be disturbed when sufficient alternative prey is available [26].

The system of crop diversity management by intercropping rice of traditional and hybrid rice varieties provides an effective way to control rice disease, increase yields, and reduce fertilizer requirements [32,33]. In this study, four rice varieties’ intercropping can reduce tungro disease and GLH population and increase natural enemies population. It is likely that with the presence of different varieties in one area, besides increasing natural enemies that can play an important role in the management of GLH, the movement of GLH is limited. Therefore, the role of GLH in transmitting of tungro virus is reduced and consequently less incidence by the disease in intercropping varieties compared to monoculture.

4. Conclusions
The incidence of tungro disease was less prevalent in four varieties of intercropping consisted of Cihera 32, Inpari 38 and IR 64 if it is compared with the monoculture of each variety. The intercropping reduced the population of green leafhopper vector (N. virescens) and the increased the predators in line with this less stringency. Therefore, controlling tungro disease and its vector can potentially use the application of rice varieties intercropping.

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