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Intercropping of Rice Varieties Reduces Green Leafhopper andWhite Stem Borer Infestation

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Abstract

A system of crop management by intercropping of diverse rice varieties in the field provides an effective way to control rice disease, but its effectiveness to control rice pest insects is not well known. Our research evaluated the impact of four rice varieties planted by strip intercropping on populations of green leaf hopper *Nephotettix virescens* and incidence of rice white stem borer *Scirpophaga innotata* in Sulawesi, Indonesia. The average number of green leafhopper insects caught by five consecutive passes with a sweep net on Pulut putih, Lapang, Fatmawati, Ciliwung varieties planted by monoculture, between 30 and 58 days after planting in a Sidrap plantation was respectively 0.6 - 4.3, 1.0 - 6.0, 1.7 - 6.7 and 2.3 - 6.0 adults, while in rice grown in strip intercropping the catch was respectively 0.7 - 2.5, 0.4 - 2.7, 0.5 - 2.6, and 1.4 - 3.5 adults. The average incidence of white stem borer observed between 30 and 65 days after planting on the same varieties in Sidrap planted by monoculture was respectively 1.8 – 9.7, 5 – 40%, 10.0 – 23.2, and 0.0 - 28.5% and in the strip intercropping was respectively 1.5 – 11.6%, 8.0 – 27.5%, 4.2 – 12.8%, and 2.0 – 7.2%. The average incidence of white stem borer in the Wajo plantation using monoculture was respectively 22.5 – 35.4%, 30.2 – 60.5%, 24.0 – 35.0%, and 17.5 – 28.5% and in the rice planted by strip intercropping was respectively 26.0 – 36.1%, 28.1 – 57.0%, 24.0 – 35.0%, and 15.0 – 23.2%. These data demonstrate that intercropping of rice varieties results in a reduction of rice pest infestation.

Keywords: Incidence, Monoculture, Pest, Population, Rice Cultivation

1. Introduction

Rice (Oryza sativa L) is an important cereal that has become one of the world's most widely grown crops. Consumption of rice constitutes about 20% of the world's caloric intake, and in Asian countries, rice represents over 50% of the calories consumed[1]. Since the first release of the rice variety IR 8 in mid-1960, the intensive cultivation of modern varieties with high yielding and pest resistance characteristics continues to the present day to ensure stable and sustainable rice production. A disadvantage of the widespread adoption of these varieties is that it leads to genetic erosion. Traditional varieties in agro-ecosystem are replaced with a narrow spectrum ofvarieties grown in monoculture which can increase infestation of some pests[2,3].

Genetic diversity is known to substantially reduce a crop's vulnerability to diseases, particularly in the tropics where many rice pathogens cause varying degrees of damage[4]. The system of crop diversity management by intercropping of traditional and hybrid rice varieties provides an effective way to control rice disease (such as blast), increase yields, and reduce fertilizer requirements[5,6]. In addition, the application of this method leads to extension of the use of traditional varieties that are economically important[6]. The data concerning the impact of varieties intercropping on pests development in rice is not well documented. However, studies of rice intercropping with other species of crops have been reported. Intercropping of upland rice with groundnut at densities between 100,000 and 200,000 plants per hectare resulted in lower green stink bug Nezara viridula and stem borer

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Chilo zacconius infestations in rice compared with rice monoculture[7].Adding more species to a cropping system can directly affect herbivorous insects in searching behavior of the host plant and indirectly affect insects in their interaction with natural enemies due to alteration of microclimatic conditions and host plant quality[8,9]. This direct and indirect impact of herbivorous insects may also be affected by the addition of more varieties that are genetically divergent to the established cropping system. Base on this reasoning, we planned to evaluate whether strip intercropping of varieties provides an impact on infestation of pests, especially green leafhopper (*Nephotettix virescens* Distant) and white stem borer *(Scirpophaga innotata* Wlk.) that predominate at present in Sulawesi, Indonesia. Green Leafhopper (GLH) is considered as a serious pest in many growing rice countries in Asia. This insect causes direct damage by sucking the sap from vascular tissues and reduces the vigor, number of tillers and yield of rice[10]. In addition to direct plant damage, the GLH also destructs rice plants by transmitting the tungro virus[11,12]. White Stem Borer (WSB) is also a serious pest infesting rice at all stages of growth[13,14]. When the infestation occurs at the vegetative stage, it causes death of tillers, while when the infestation occurs at the generative stage, empty panicles result[15]. The primary objective of this research was to evaluate the effect of strip intercropping of rice varieties adopting the Legowo Model (LM) on population dynamics of green leafhopper, N. virescens and incidence by white stem borer, S. *innotata* on rice. The LM is a method of planting rice using a pattern of row crops interspersed with empty rows. In this study, rice varieties intercropped in this LM consisted of two traditional varieties and two modern varieties. The study was located in Sidrap Regency and Wajo Regency, South Sulawesi.

2. Materials and Methods

2.1 Research Location and Rice Varieties

The research was done on the West Coast of Sulawesi in Sidrap Regency and on the East Coast of Sulawesi in Wajo Regency. The first site is an endemic region of green leafhopper, while the second site is not. White stem borer infests rice in these two regions in the same manner. Four varieties were used in this research consisting of two modern varieties (Ciliwung and Fatmawati) and two traditional varieties (Pulut putih and Lapang). Ciliwung variety is resistant to brown leafhopper strain 1 and 2 and green leafhopper, while Fatmawati is mildly resistant to brown leafhopper strain 3 and resistant to bacterial leaf blight. No data is available concerning the degree resistance of the two traditional varieties to pests and diseases.

2.2 Rice Planting and Research Design

The rice planting was done at the same time when the season in Sidrap. Regency was dry and in Wajo Regency was wet. The experiment was designed with a randomized block design with eight treatments and each treatment was repeated three times. Four treatments consisted of four varieties planted in intercropping strips in one plot and varieties planted in monoculture in separate plots. For the intercropping treatment, rice was planted using the Legowo Model forming eight block rows of varieties in plot of 20 m x 40 m, while for the monoculture treatment, each rice variety was planted homogenously in plots of 10 m x 40 m. The rice seed was planted directly at an inter planting distance of 20 cm x 20 cm.

2.3 Assessment of Pest Population and Rice Incidence

Assessments were conducted on populations of green leafhopper and infestation by white stem borer. To determine the population of green leafhopper, five spots representing each treatment plot were selected and in each spot, adult flying insects were captured by sweep net with five consecutive swings. This population was observed over one month from 30 days to 58 days after planting with an interval of seven days.

To measure the incidence by white stem borer, 25 samples of rice hill were taken diagonally and the total in each treatment consisted of 75 hills. This incidence was observed for one month from 30 days until 65 days after planting with an interval of seven days and calculated according to formula of $I = a/b \times 100\%$ where 'I' is incidence, 'a' is number of tillers infested, and 'b' is total number of tillers observed in one hill.

2.4 Analysis

The data of green leafhopper population and incidence by white stem borer were analyzed without any transformation. T-tests were then used to evaluate significant differences between the treatment means on each variety planted in monoculture and in intercropping. To evaluate whether significant differences for population and incidence between varieties occurred, Least Significant Difference (LSD) tests were used.

3. Results

Green leafhopper was only observed in its endemic region, Sidrap regency, and not observed in Wajo regency. Its population was high in young rice and decreased with increasing age of rice plants. The pest population on all varieties and at the same age in rice grown in monoculture was apparently similar on the different rice varieties but it decreased when rice varieties were planted by intercropping. On rice of Pulut putih, Lapang, Fatmawati, and Ciliwung varieties planted in monoculture observed at 30 days to 58 days after planting, the population of green leafhopper caught by five consecutive passes with a sweep net was respectively in range of 0.6 - 4.3 adults, 1.0 - 6.0 adults, 1.7 - 6.7 adults and 2.3 - 6.0 adults, while on rice planted in strip intercropping the catch was respectively in range of 0.7 - 2.5 adults, 0.4 - 2.7 adults, 0.5 - 2.6 adults, and 1.4 - 3.5 adults. This difference was significant (P = 0.05) when the population of GLH in monoculture was relatively high (Figure 1). Comparing on each of these four varieties, the population of GLH was not significantly different (P = 0.05). The incidence of rice caused by white rice borer was observed both in Sidrap Regency and in Wajo regency, but in Sidrap this incidence was lower than in Wajo. In Sidrap, the average incidence on rice of Pulut putih, Lapang, Fatmawati, Ciliwung varieties planted in monoculture and examined at 30 days to 65 days after planting was respectively in the range of 1.5 - 9.7%, 5.0 - 40.0%, 10.0 - 23.2%, and 0.0 - 28.5%. While, the incidence examined on the same day on rice of the same varieties planted by intercropping was respectively in the range of 1.5 - 11.6%, 8.0 - 27.5%, 4.2 - 12.8%, and 2.0 - 8.0%. A significant difference (P = 0.05) indicating that incidence in intercropping is lower than in monoculture on all varieties was occurred after the first observation (Figure 1). Comparing the peak incidence of WSB between varieties indicated that the incidence on Lapang variety was significantly different (P = 0.05) from the three other varieties, while among these three varieties no significant difference was detected. In Wajo, the average incidence on rice of Pulut putih, Lapang, Fatmawati and Ciliwung planted in monoculture was respectively in the range of 22.5 – 35.4%, 30.2 – 60.5%, 24.0 – 35.0%, and 17.5 – 28.5%, while incidence on the same varieties planted by intercropping was respectively 26.0 – 36.1, 28.1 – 57.0%, 24.0 – 35.0%, and 15.0 – 23.2% (Figure 3). The lower incidence in intercropping compared to varieties grown in monoculture was significant (P = 0.05) for Lapang and Ciliwung varieties (Figure 2). With the exception of the Pulut putih and Fatmawati varieties, the incidence between varieties was significantly different (P = 0.05).

4. Discussion

On four rice varieties tested in Sidrap, the population of GLH was relatively similar, this indicates that GLH possibly can transmit the same quantity of rice tungro virus to these four varieties. N. virescens is the most effective vector in transmitting the tungro virus[11,12]. Ciliwung variety is relatively resistant to tungro virus[16] and since its release in 1988, this variety has been planted until the present day by farmers in Sulawesi. Based on Ciliwung variety and GLH population data, the other three varieties are also apparently resistant to tungro virus. The GLH population decreased with increasing rice plant age. This was correlated with seasonal decreases in GLH population. The population peak of GLH is reached in the months of March April[16] and in this trial, the rice was planted in May. WSB incidence depends on planting time and variety planted in the field[15]. Females of the stem borer lay eggs on the leaves and these eggs hatch within a few minutes of each other. Then, larvae crawl out to the leaf tips, some descend on silk threads and balloon to other rice hills or fall into the water and swim to colonize a rice plant[13.] A high amount of water in the rainy season can help dispersal and infestation of this pest and higher incidence of WSB in Wajo than Sidrap was perhaps correlated with wetter conditions in Wajo. Also, the populations of WSB natural enemies, such as *Trichogramma* sp., *Telenomus sp*. and *Tetrastichus* sp. were lower in the wet season than in the dry season[17]. The highest incidence of WSB in Sulawesi rice plantation has been reported to be around 30%-35% (Patihong, personal communication), but we found the incidence on Lapang traditional variety reached 60%. This mean that Lapang variety can be classified as moderately susceptible to WSB.

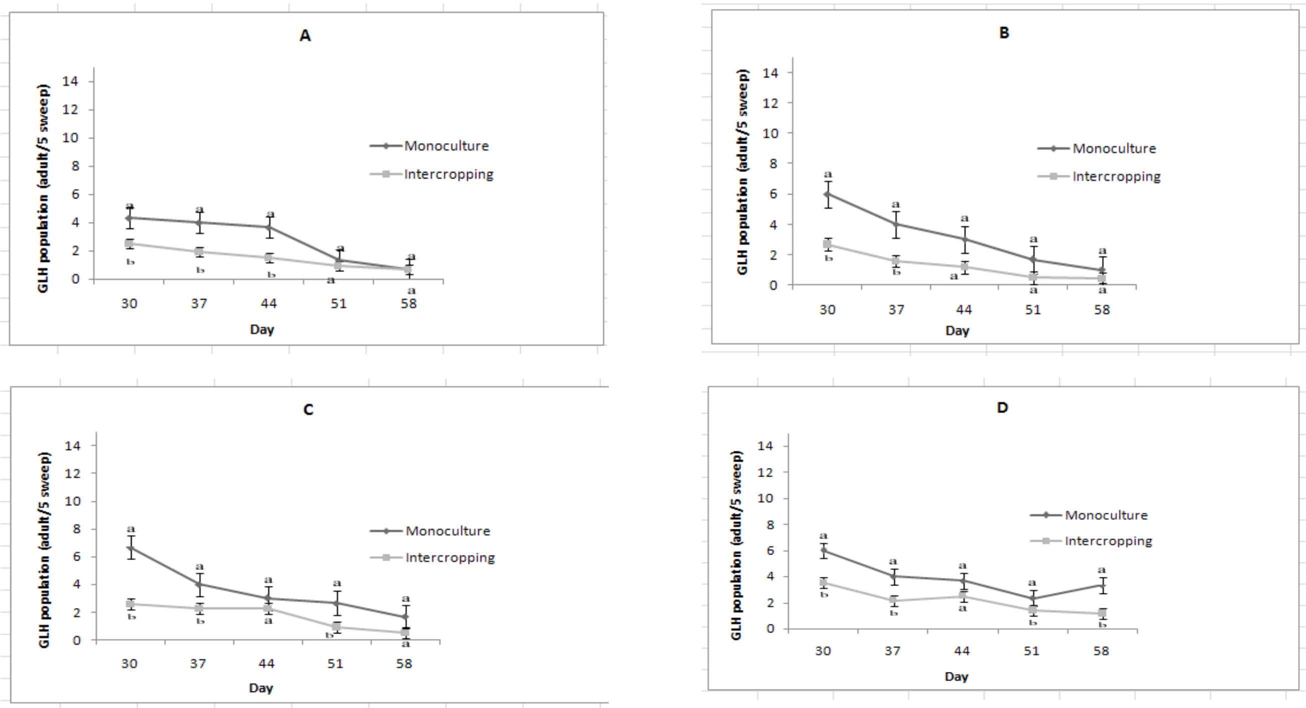

Figure 1. Population dynamic of green leafhopper, Nephotettix virescent (adult/5 sweep) on rice varieties of Pulut Putih (A), Lapang (B), Fatmawati (C) and Ciliwung (D) planted in monoculture and in strip intercropping in Sidrap Regency. Means in the same day followed by same letter are not significantly different according to 5% T-test.

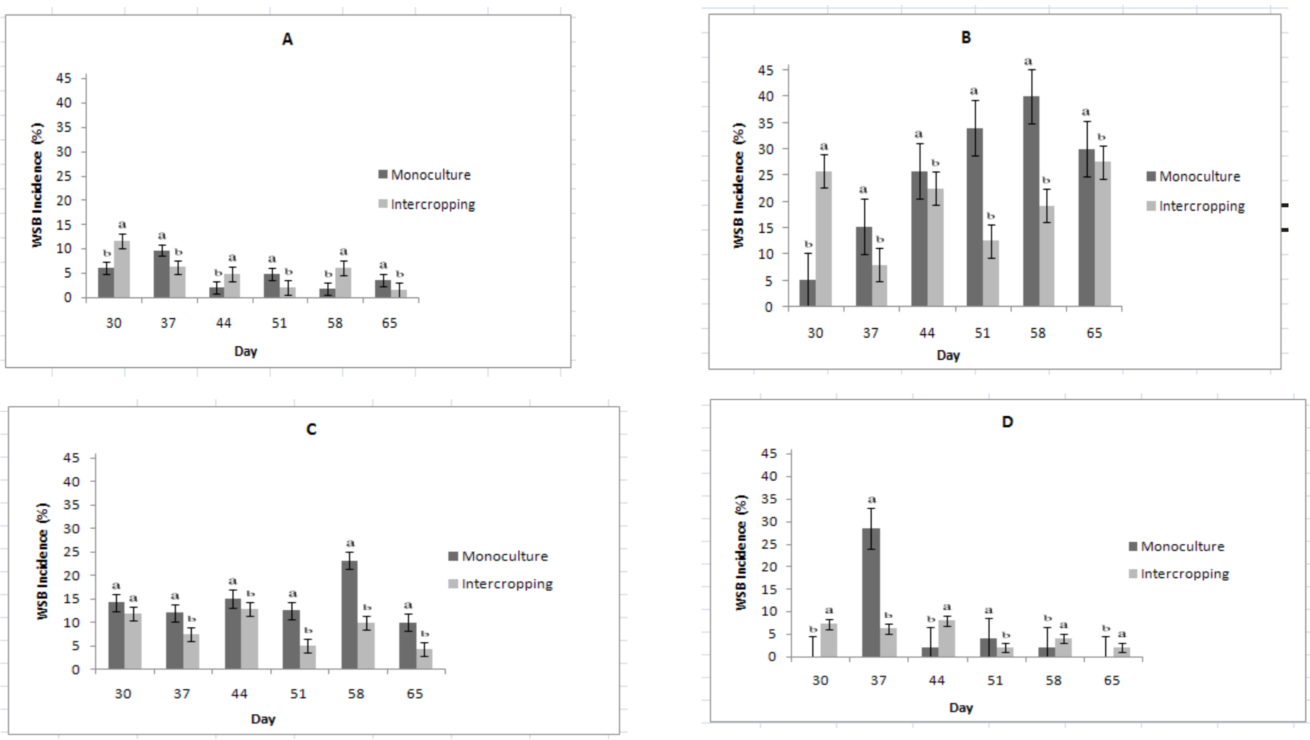

Figure 2. The incidence by white stem borer, Scirpophaga innotata (%) on rice varieties of Pulut putih (A), Lapang (B), Fatmawati (C) and Ciliwung (D) planted in monoculture and by strip intercropping in Sidrap Regency. Means in the same day followed by same letter are not significantly different according to 5% T-test.

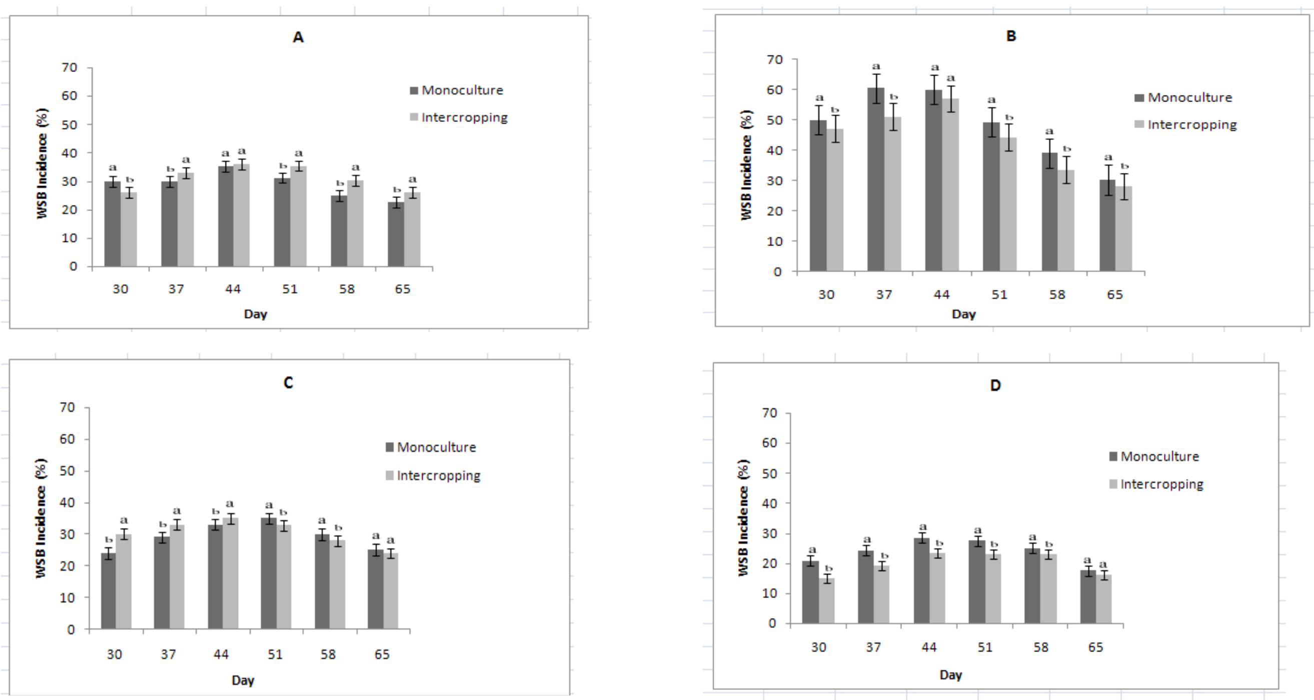

Figure 3. The incidence of white stem borer, Scirpophaga innotata (%) on rice varieties of PulutPutih (A), Lapang (B), Fatmawati (C) and Ciliwung (D) planted in monoculture and by strip intercropping in Wajo Regency. Means in the same day followed by same letter are not significantly different according to 5% T-test.

Contrary to this variety, the other traditional variety (Pulut putih) was apparently comparable to Ciliwung and Fatmawati varieties in the degree of resistance to WSB. Compared with a monoculture, adding more rice varieties to a cropping system using Legowo Model (LM), can apparently affect green leafhopper and white stem borer in three ways. Firstly, the environment of rice such as temperature is altered. More free space between varieties due to LM and alternation between short and tall varieties permits the crop to receive more sunshine and consequently temperature become higher than in monoculture. The development period of nymphal, pre-oviposition and ovisition periods, and egg lying capacity of the GLH female decreased with increase in temperature[18]. Secondly, the impact induced by plant genotype either due to environmental change or its genetic make up lead to differences in nutritional quality of rice varieties[19]. In the case of the white stem borer, a study showed variation in the shape of the mandible among populations of this insect taken from different rice varieties, but not in the same variety collected from different geographical locations of Philippines[20]. The mandible is used by white stem borer to penetrate and feed on its plant host. Therefore, changes in environment and nutritional quality of rice due to varieties intercropping system would lead also to a direct effect on the host variety searching behavior of pest insects. Thirdly, the genetic variation in the intercrop system can affect the abundance and efficiency of the natural enemies which depend on habitat complexity for resources[21]. The impact of application of this intercropping system on WSB infestation was seen uniformly on four varieties in Sidrap trial and also in Bone trial (data not presented here), while responses in Wajo trial were only observed on Lapang and Ciliwung varieties. High winds besides water due to rainy season in Wajo probably affect insect dispersal and infestation of preferable varieties. The distance and direction of dispersal of ballooning stem borer larvae was influenced by wind speed and direction[13]. We found that the peak incidence of WSB on each rice varieties in monoculture in Sidrap did not occur on the same day as the peak incidence in intercropping. This suggested that the dispersal of insects was disturbed by intercropping. On the contrary, in Wajo the incidence peak in monoculture was parallel with that in intercropping: the insect infested rice planted in monoculture and rice planted in intercropping at the same time.This is probably due to physical factors contributing to dispersion of the insect. Our results provide new insights into control of insect pests by using spatial diversification through planting several rice varieties at the same time. In Sulawesi Indonesia, we have succeeded to control two pests by adjustment of planting time and rotation of varieties or temporal diversification. However under actual condition of rice production at present, the first method can not be implemented in some rice growing area due to a limitation of water availability, while the second method cannot be fully implemented due to limitation of seeds for seedling. The management of variety diversity by strip intercropping makes it possible to conserve farm traditional varieties that may be important for sustainable production. The traditional variety, Pulut putih, is adapted to be planting both in wet season and dry season. Additionally, the traditional variety, Lapang, can be planted in dry season conditions in a mixture with other varieties.

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