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*Research Article*

# Dynamics of weeds and main pests in different rice planting systems supplemented with biodecomposer

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**ABSTRACT**

*Biodecomposers are used as an alternative in pest and weed management by utilizing antagonistic microbes. This study aimed to identify the optimal treatment for suppressing weed growth and controlling the main rice pests, promoting environmentally friendly agricultural practices. Observations were made on three phases of rice growth on land that used biodecomposer and did not use biodecomposer. Weed sampling used a quadrant, which represents each treatment. All weeds were analyzed for density and summed dominance ratio. Pests were observed from the sweep net method. Pests were analyzed with the Shannon-Wiener diversity index (H'). Ten species of weeds are found; the most common and dominant was Cyperus difformis, while the least were Ipomoea aquatica and Ludwigia octovalvis. There were seven pest species; the most common was Nephothettix virescens, while the least was Valanga nigricornis. Using bio-decomposers combined with a two-row planting system was effective in suppressing the development of weeds and pests with a decreasing trend as the rice growing phase increases. Biodecomposers are environmentally friendly even though the process is slow, and have the potential to reduce weeds and pests.*

**Keywords:** biodecomposers, Jarwo 2:1, Tegel, trichoderma

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## INTRODUCTION

Weeds and major pests are the limiting factors in increasing rice productivity, currently, the common way to control tends to use pesticides, while the continuous use of herbicides will result in the evolution of weeds to become more resistant (Usman et al., 2016). The high dependence of farmers on these materials causes their use to be excessive and has an impact on environmental pollution. Most of the pesticides that are sprayed on rice plants fall to the ground, either directly or indirectly exposed around the cultivation area (Hutter et al., 2021), and have broad toxic properties (Bashir et al., 2018), so pesticides currently have global attention.

Environmentally friendly rice management is an alternative to deal with this problem by reducing synthetic pesticides. Biocontrol of weeds (Telkar et al., 2015), pests, and diseases (Istiqomah et al., 2022) in rice plants using pathogenic fungi has become a trend in developed countries because apart from being quite effective like chemical control, it also has very negative side effect to the environment. The research and use of biocontrol products such as microorganisms and natural ingredients for plant protection are currently being prioritized (Triolet et al., 2019).

Biodecomposers including bacteria, fungi, and *Actinomycetes*, are organisms responsible for decomposing carbon and nitrogen from the organic remains of dead plant or animal tissues, which can be apart from being used to accelerate the process of decomposition of plant residues, these microorganisms also increase soil biomass and microbial activity, reduce disease, insect larvae, and weed seeds so that their use can increase soil fertility and health (Saraswati & Praptana, 2021). Fungi have better decomposer ability than bacteria. Decomposing fungi can also inhibit the growth of plant pests (Irianti & Suyanto, 2016). One of the secondary metabolite products of *Trichoderma* spp is a steroid compound which produces viridiol molecules (Berlian et al., 2013). Viridiol molecules obtained from Trichoderma can act as herbicides (Cornejo et al., 2016) so they can control weeds significantly (Heraux et al., 2005).

The distance rice planting system consists of two, namely the Tegel system and the double row planting system (Jarwo 2:1). The Tegel system plants rice with a space of 25 x 25 cm, while the Jarwo 2:1 system consists of two rows and one empty row with a closer spacing or ½ times the spacing between rows (12.5 x 25 cm). The double-row planting system is more effective than the Tegel. Research by Hamdani and Murtiani (2014) shows that the double-row planting system has longer panicles, the number of filled grains is greater, and the weight of 1000 seeds is heavier than the Tegel system. When combined with biodecomposers, the double-row planting system is expected to reduce weed populations and major pests in rice. This study aimed to identify the optimal treatment for suppressing weed growth and controlling the main rice pests, promoting environmentally friendly agricultural practices.

**MATERIALS AND METHODS**

This research was conducted in Sidrap, South Sulawesi, on the first season plant (MT I) in 2022. The research used two planting systems, namely the double-row planting system (Jarwo 2:1) and the single-row planting system (Tegel) (Figure 1), in combination with and without biodecomposers. So, there were four treatments, Jarwo 2:1 without biodecomposer; Jarwo 2:1 with biodecomposer; Tegel without biodecomposer, and Tegel with biodecomposer. Soil embankment was made to separate among treatments. The biodecomposer is a product formulation containing *Trichoderma* sp. 10.20 x $10^7$ propagules $g^{-1}$ *Aspergillus* sp. 1.0 x $10^7$ propagules $g^{-1}$, and *Trametes* sp. 2.0x $10^7$ propagules $g^{-1}$. The research used was simple random sampling. Weed and pests sampling was carried out in three phases in rice cultivation, namely the early vegetative phase (water ponding condition), late vegetative (saturated condition), and generative phase (dry condition).

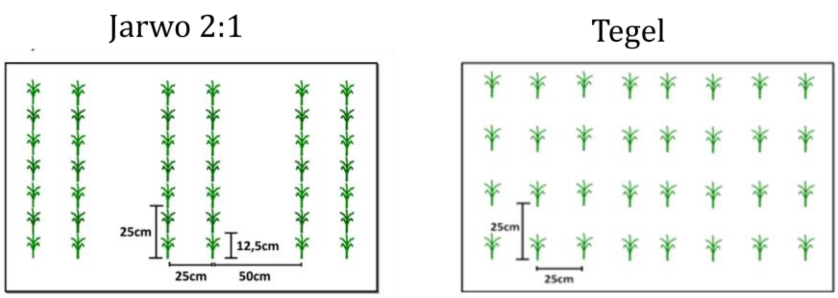



Figure 1. The comparison of Jarwo and Tegel planting systems.

*Weed analysis*

Weed sampling used a quadrant consisting of five 1 m x 1 m sample plots which represent each treatment. All weeds in each plot were collected. Weeds that have been observed in each block were removed mechanically. The weeds obtained were identified and analyzed—weed ecological analysis based on Pertiwi and Arsyad (2016).

Density is related to the weed population in each plot. Weeds were evaluated based on the species in the plot, and then the number of weeds was counted:

$$Relative\ Density\ (RD\%) = \frac{Absolute\ density\ for\ a\ specific\ species}{Total\ absolute\ density\ for\ all\ species} x100$$

$$\textbf{Relative Frequency (RF)} = \frac{\textbf{Absolute frequency value for a specific species}}{\textbf{Total absolute frequency values for all species}} \times 100$$

The SDR value or the Total Dominance Value can be calculated using the following formula:

$$\textbf{Summed Dominance Ratio (SDR)} = \frac{\textbf{Relative Density} + \textbf{Relative Frequency}}{\textbf{2}}$$

*Pests analysis*

Pest sampling was carried out using the sweep net method using an insect net 10 times double swings diagonally. All pests in each plot were collected in small bottles and labeled. Then, counted and identified based on the book "Key of Insect Determination" (Sulthoni et al., 1991) and the book "Natural Enemies of Rice Pests"(Shepard et al., 2011).

Shannon-Wiener diversity index (H') was implemented. The pest species diversity index in each treatment was calculated using the Shannon-Wiener formula (Magguran, 2005) with the following formula:

$$\mathrm{H}' = \sum_{i=l}^{n} Pi \ln Pi$$

The indications of the species diversity index according to Shannon-Wiener are as follows:

- The value of H'>3 indicates that species diversity is abundant (high) with a high number of individuals.
- The value of H' between 1 and 3 (1≤H'≤3) indicates that the species diversity is moderate
- The value of H'≤1 indicates that the species diversity is little or low.

## RESULTS AND DISCUSSION

*Weeds analysis*

Table 1 shows the double row planting system cropping system with biodecomposers found fewer weed species, namely 4 weed species in the initial vegetative phase, 4 weed species in the final vegetative phase, and no weeds were found in the generative phase. Followed by a Tegel planting system using an initial vegetative phase biodecomposer found 6 species of weeds in the initial vegetative phase, 3 species of weeds in the late vegetative phase, and 2 species of weeds in the generative phase. On plots using biodecomposers, weeds *Leersia hexandra, Cyperus iria, Ipomea aquatica,* and *Ludwigia octovalvis* were not found in all rice growth phases, both in the double row planting system and the Tegel cropping system. Many weeds disappeared from the field as the rice growth phase increased. According to Perianto et al. (2016), morphologically, weeds are classified into grasses, sedges, and broadleaf. From a total of 10 species, grasses, sedges, and broadleaf were 3, 3, and 4 species, respectively.

The SDR value describes the ability of weeds to dominate existing growing media. The higher the SDR value, the more dominant weeds will be (Table 2). The initial vegetative phase with water ponding conditions showed the highest average relative frequency, relative density, and SDR values in the sedges group, namely *Cyperus difformis*, in all treatments. This weed is also reported to dominate rainfed land (Firmansyah & Haiqal, 2022) to swampland (Syaifuddin et al., 2022). In the double row planting system treatment using the biodecomposer, the SDR value even reached 52%, with an average range in each treatment of 39-52%. In addition, the SDR value of > 20% was still dominated by the sedge group, namely *F. miliaceae* in the treatment without-biodecomposers and for the broadleaf weeds *M. vaginalis* in the biodecomposer treatment, respectively in both cropping systems.

Table 1. Presence of weeds in various cropping systems and the use of biodecomposers in the three growth phases of rice.

| Weed species | Descriptor | Weed group | Jarwo 2:1 without biodec | | | Jarwo 2:1 with biodec | | | Tegel without biodec | | | Tegel with biodec | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | IV | FV | G | IV | FV | G | IV | FV | G | IV | FV | G |
| *Leptochloa chinensis* | Growth habit: tufted, erect, and slender; sometimes with reclining stems; up to 1.2 m Moisture: aquatic-wet to flooded, Life cycle: perennial | Grasses | + | + | + | - | - | - | + | + | + | + | - | - |
| *Echinochloa colonum* | Growth habit: tufted and erect; up to 0.6 m, Moisture: dry to wet, Life cycle: perennial | Grasses | + | + | + | + | + | - | + | + | - | + | - | - |
| *Leersia hexandra* | Growth habit: creeping to ascending, tufted, and erect; up to 1.2 m Moisture: aquatic-flooded to wet, Life cycle: perennial | Grasses | + | + | - | - | - | - | - | - | - | - | - | - |
| *Cyperus iria* | Growth habit: erect; tufted up to 0.8 m, Moisture: moist to wet, Life cycle: annual | Sedges | + | + | - | - | - | - | + | + | - | - | - | - |
| *Fimbristylis miliaceae* | Growth habit: erect and strongly tillering; up to 0.6 m Moisture: moist to wet, Life cycle: perennial | Sedges | + | + | + | + | + | - | + | + | + | + | + | + |
| *Cyperus difformis* | Growth habit: tufted and erect; up to 1.0 m Moisture: wet to moist, Life cycle: annual | Sedges | + | + | + | + | + | - | + | + | - | + | + | - |
| *Monochoria vaginalis* | Growth habit: herb; erect, hairless and fleshy; up to | Broad-leaved | + | + | - | + | + | - | + | + | - | + | + | + |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0.5 m, Moisture: aquatic—wet to flooded, Life cycle: perennial | | | | | | | | | | | | | |
| *Ipomoea aquatica* | Growth habit: vine, widely spreading and much-branched, Moisture: aquatic—flooded to wet, Life cycle: perennial | Broad-leaved | + | - | - | - | - | - | - | - | - | - | - | - |
| *Ludwigia octovalvis* | Growth habit: erect, much-branched and robust herb; up to 1.5 m Moisture: wet to damp; drier than L. adscendens, Life cycle: perennial | Broad-leaved | - | - | - | - | - | - | + | - | - | - | - | - |
| *Limnocharis flava* | Growth habit : Erect, Height reaches 20-50 cm. Moisture: aquatic-wet to flooded, Life Cycle : Annuals | Broad-leaved | - | - | - | - | + | - | - | - | - | + | - | - |

*Note:* IV=Initial Vegetative, FV=Final Vegetative, G= Generative. (+) found in certain types of weeds in the observation block. (-) no certain weed species were found in the observation plot. Description of weed cited from Caton et al. (2010).

The final vegetative phase with saturation conditions shows a change in the dominance of weed vegetation. Using biodecomposers in all cropping systems showed that *F. miliacea* had the highest SDR value. This is similar to vegetation in the generative phase with dry land conditions; *F.miliaceas* still predominates with high SDR values. Then for biodecomposers in all cropping systems dominated by broadleaf weeds, interestingly, the use of biodecomposers in the double row planting system cropping system in the generative phase did not find weeds. This is due to the presence of fungi contained in biodecomposers which can suppress weed growth. One of the fungi contained in the biodecomposers used is *Trichoderma*. Several species of *Trichoderma* have also been reported as biological agents for weed control, for example, *Trichoderma harzianum* Rifai, *Trichoderma virens* (Miller, Giddens & Foster) Von Arx, *Trichoderma reesei* EG Simmon, *Trichoderma pseudokoningii* Rifai and *Trichoderma viride* Pers (Heraux et al., 2005.; Javaid & Ali, 2011)

Table 2. Relative frequency, relative density, and total dominance of weeds in the four treatments and three growth phases of rice.

| Treatment | Weed species | Initial vegetative | | | Final vegetative | | | Generative | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | RD | RF | SDR | RD | RF | SDR | RD | RF | SDR |
| Jarwo 2:1 without bio dec | *L. chinensis* | 14.29 | 3.32 | 8.80 | 23.08 | 19.44 | 21.26 | 33.33 | 4.72 | 19.03 |
| | *E. colonum* | 9.52 | 1.11 | 5.32 | 7.69 | 6.94 | 7.32 | 13.33 | 3.15 | 8.24 |
| | *L. hexandra* | 4.76 | 0.16 | 2.46 | 7.69 | 4.17 | 5.93 | 0.00 | 0.00 | 0.00 |
| | *C. iria* | 4.76 | 0.16 | 2.46 | 7.69 | 2.78 | 5.24 | 0.00 | 0.00 | 0.00 |
| | *F. miliaceae* L. | 28.57 | 44.30 | 36.44 | 38.46 | 62.50 | 50.48 | 40.00 | 89.76 | 64.88 |
| | *C. difformis* | 28.57 | 50.63 | 39.60 | 7.69 | 2.78 | 5.24 | 13.33 | 2.36 | 7.85 |
| | *M. vaginalis* | 4.76 | 0.16 | 2.46 | 7.69 | 1.39 | 4.54 | 0.00 | 0.00 | 0.00 |
| | *I. aquatica* | 4.76 | 0.16 | 2.46 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | *L. octovalvis* | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | *L. flava* | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Jarwo 2:1 with biodec | *L. chinensis* | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | *E. colonum* | 6.24 | 2.02 | 4.13 | 9.09 | 18.61 | 13.85 | 0.00 | 0.00 | 0.00 |
| | *L. hexandra* | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | *C. iria* | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | *F. miliaceae* L. | 6.24 | 0.41 | 3.32 | 9.09 | 4.65 | 6.87 | 0.00 | 0.00 | 0.00 |
| | *C. difformis* | 31.21 | 72.87 | 52.04 | 18.18 | 25.58 | 21.88 | 0.00 | 0.00 | 0.00 |
| | *M. vaginalis* | 31.21 | 20.24 | 25.73 | 36.36 | 32.56 | 34.46 | 0.00 | 0.00 | 0.00 |
| | *I. aquatica* | 0.00 | 0,00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | *L. octovalvis* | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | *L. flava* | 24.97 | 4.45 | 14.71 | 27.27 | 18.61 | 22.94 | 0.00 | 0.00 | 0.00 |
| Tegel without bio dec | *L. chinensis* | 20.00 | 1.85 | 10.93 | 26.32 | 9.80 | 18.06 | 14.29 | 2.42 | 8.35 |
| | *E. colonum* | 13.33 | 0.69 | 7.01 | 10.53 | 2.61 | 6.57 | 0.00 | 0.00 | 0.00 |
| | *L. hexandra* | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | *C. iria* | 6.67 | 0.14 | 3.40 | 5.26 | 0.65 | 2.96 | 0.00 | 0.00 | 0.00 |
| | *F. miliaceae* L. | 20.00 | 20.72 | 20.36 | 21.05 | 38.56 | 29.81 | 85.71 | 97.58 | 91.65 |
| | *C. difformis* | 20.00 | 75.20 | 47.60 | 15.79 | 41.18 | 28.48 | 0.00 | 0.00 | 0.00 |
| | *M. vaginalis* | 16.67 | 1.30 | 8.99 | 21.05 | 7.19 | 14.12 | 0.00 | 0.00 | 0.00 |
| | *I. aquatica* | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | *L. octovalvis* | 3.33 | 0.07 | 1.70 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | *L. flava* | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Tegel with biodec | *L. chinensis* | 20.00 | 5.51 | 12.75 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | *E. colonum* | 6.67 | 0.46 | 3.56 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | *L. hexandra* | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | *C. iria* | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | *F. miliaceae* L. | 6.67 | 0.92 | 3.79 | 14.29 | 10.00 | 12.14 | 16.67 | 16.67 | 16.67 |
| | *C. difformis* | 20.00 | 59.17 | 39.59 | 14.29 | 12.50 | 13.39 | 0.00 | 0.00 | 0.00 |
| | *M. vaginalis* | 40.00 | 33.03 | 36.51 | 71.43 | 77.50 | 74.46 | 83.33 | 83.33 | 83.33 |
| | *I. aquatica* | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | *L. octovalvis* | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | *L. flava* | 6.67 | 0.92 | 3.79 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

*Note:* RD = relative density, RF = relative frequency, SDR = summed dominance ratio.

*Pests analysis*

Seven pests attacked rice during the early vegetative to generative stages (Table 3). The Jarwo without biodecomposers had the highest pest populations (5 species at the initial vegetative phase, and 4 species for each of the final vegetative and generative phases). In the treatment of the Tegel row planting system number of species was similar between with and without biodecomposers treatment, although species name was slightly different biodecomposer. The high population of green leafhoppers was caused by several supporting factors, including climate, soil, biological factors, and host plants. Some weeds could be alternative hosts for shelter, food sources, and places to lay eggs. According to Ladja (2013), there are 4 dominant weed species used as alternative hosts for *Nephotettix virescens,* namely *Leersia hexandra, Cynodon dactylon, Echinochloa crus-galli,* and *Echinochloa indica*. According to Praptana and Senoaji (2017), weeds can act as alternative hosts for pests and can indirectly as the limiting factors in increasing rice crop production.

Table 3. Presence of rice pests in different planting systems and biodecomposers at different growing phases.

| Pest species | Family | Jarwo 2:1 without biodec | | | Jarwo 2:1 with biodec | | | Tegel without biodec | | | Tegel with biodec | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | IV | FV | G | IV | FV | G | IV | FV | G | IV | FV | G |
| *Nephotettix virescens* | Cicadellidae | + | + | + | + | + | + | + | + | + | + | + | + |
| *Nilaparvata lugens* | Delphacidae | + | + | + | + | + | + | + | + | - | + | + | + |
| *Scirphopaga innotata* | Phyrallidae | + | - | - | + | - | - | + | + | - | + | - | - |
| *Nymphula depunctalis* | Crambidae | + | + | - | + | + | - | + | + | - | + | + | + |
| *Leptocoriza acuta* | Alydidae | - | - | + | - | - | - | - | - | + | - | - | - |
| *Valanga nigricornis* | Acrididae | - | - | - | - | - | + | - | - | - | - | - | - |
| *Recilia dorsalis* | Cicacadellidae | + | + | + | - | - | + | - | + | + | - | + | - |

*Note:* IV=Initial Vegetative, FV=Final Vegetative, G= Generative. (+) is found in certain pests in the observation block. (-) no certain pest species were found in the observation block.

Table 4 shows the mean values of the species which varied between treatments in the three growth phases of rice. The highest mean species value was found in the Tegel cropping system without biodecomposers in the initial vegetative phase, with the highest species being *N. virescens* (Cicadellidae: Hemiptera), while the lowest species average value was in the double row planting system with biodecomposers.

The diversity index (H') of pests in biodecomposers treatments tends to be low. This is because biodecomposer contains fungi which can be used as biological agents. Most biological controls use the help of various organisms or their toxic metabolites to prevent pest, disease, and weed activity. Some entomopathogenic fungi can kill their hosts more quickly by releasing several mycotoxins (such as beauvericin, cyclodepsipeptide, destruxin, and desmethyl-destruxin) in the early stages of infestation. Toxigenic fungi able to kill its host earlier compared to non-toxigenic species (Wang et al., 2018; Altinok et al., 2019). The effect of treatment at various growth phases of rice against the main weeds and pests.

The sedge groups of weeds were the most frequently found, namely *C. difformis* and *F. miliceaea* with a total of 1.806 and 930 individuals respectively (Figure 1). Meanwhile, the fewest weed groups are the broad-leaf weeds, namely *L. octovalvis* and *I. aquatica* with only two individuals. In line with research by Aryanti et al. (2021) who found that *C. difformis* and *F. miliaceaea* were the weeds of the sedges group that were most commonly found in lowland rice plantations. This is because sedges have stem tubers in the soil that can last for months.

The effectiveness of the bio-decomposer has more influence on broad-leaf weeds than sedges and grasses. However, further studies need to be carried out to prove this. Environmental factors and land cultivation play an important role in weed dominance. Weed seeds are usually found on the surface of the soil or buried below the surface of the soil. Generally, dormant weed seeds from last season will grow in the following season. Weeds have high adaptation or the ability to adapt and survive in unfavorable environments.

Table 4. Average and diversity index (H') in the three growth phases of rice.

| Treatments | Species | Initial vegetative | | Final vegetative | | Generative | |
|---|---|---|---|---|---|---|---|
| | | Average | H’ | Average | H’ | Average | H’ |
| Jarwo 2:1 without bio dec | *Nephotettix virescens* | 8.83 | 1.3534 | 2.05 | 1.3502 | 1.33 | 1.1522 |
| | *Nilaparvata lugens* | 11.00 | | 2.00 | | 1.00 | |
| | *Scirphopaga innotata* | 1.67 | | 0.00 | | 0.00 | |
| | *Nymphula depunctalis* | 11.00 | | 1.00 | | 0.00 | |
| | *Leptocoriza acuta* | 5.50 | | 0.00 | | 5.50 | |
| | *Valanga nigricornis* | 0.00 | | 0.00 | | 0.00 | |
| | *Recilia dorsalis* | 4.50 | | 1.50 | | 2.00 | |
| Jarwo 2:1 with bio dec | *Nephotettix virescens* | 9.67 | 0.9427 | 3.00 | 0.8599 | 4.00 | 1.2424 |
| | *Nilaparvata lugens* | 8.83 | | 1.50 | | 0.00 | |
| | *Scirphopaga innotata* | 3.00 | | 2.00 | | 0.00 | |
| | *Nymphula depunctalis* | 6.67 | | 1.67 | | 0.00 | |
| | *Leptocoriza acuta* | 7.00 | | 0.00 | | 7.00 | |
| | *Valanga nigricornis* | 0.00 | | 0.00 | | 0.00 | |
| | *Recilia dorsalis* | 5.00 | | 4.00 | | 1.00 | |
| Tegel without bio dec | *Nephotettix virescens* | 24.67 | 1.1931 | 7.00 | 1.5382 | 3.00 | 0.8876 |
| | *Nilaparvata lugens* | 15.33 | | 3.00 | | 1.00 | |
| | *Scirphopaga innotata* | 1.00 | | 0.00 | | 0.00 | |
| | *Nymphula depunctalis* | 2.00 | | 1.00 | | 0.00 | |
| | *Leptocoriza acuta* | 0.00 | | 0.00 | | 0.00 | |
| | *Valanga nigricornis* | 1.00 | | 0.00 | | 1.00 | |
| | *Recilia dorsalis* | 1.00 | | 0.00 | | 1.00 | |
| Tegel with bio dec | *Nephotettix virescens* | 20.33 | 1.3095 | 8.00 | 0.9830 | 6.33 | 0.8325 |
| | *Nilaparvata lugens* | 10.33 | | 1.00 | | 2.00 | |
| | *Scirphopaga innotata* | 1.00 | | 0.00 | | 0.00 | |
| | *Nymphula depunctalis* | 5.00 | | 2.00 | | 1.00 | |
| | *Leptocoriza acuta* | 0.00 | | 0.00 | | 0.00 | |
| | *Valanga nigricornis* | 0.00 | | 0.00 | | 0.00 | |
| | *Recilia dorsalis* | 1.00 | | 1.00 | | 0.00 | |

*Note:* H’ = Shanon-Wiener diversity index.

Regarding pest species, *N. virescens* was the most abundant, while *V. nigricornis* is the smallest pest. The effectiveness of the bio-decomposer in this study had more influence on larger insect pest species, such as *V. nigricornis*, compared to smaller pest insect species, such as *N. virescens* and *N. lugens*. There are various influencing factors, including environmental factors and plant age factors. *V. nigricornis* sucks rice grains during the generative plant phase, while *N. virescens* and *N. lugens* will migrate to young plants. This is supported by Firdaus and Haryadi (2022), who argue that the migratory nature of *N. lugens* Stal is able to maintain its life by moving to younger rice plots.

The data obtained (Figure 2) shows that the bio-decomposer treatment tends to inhibit the development of weeds in both the Tegel planting system and the Jarwo 2:1 planting system. Biodecomposers play a role in land by suppressing weed seeds during land processing until they enter the initial vegetative phase. Biodecomposers provide relatively slow working power but are safer for the environment. Rice farming conditions that include cultivation practices such as the use of chemical pesticides suppress the growth of weeds and pests more quickly but have a negative impact on food safety. Biodecomposers were found to be able to reduce pest and weed populations in this research, so they have the potential to replace chemical pesticides that grow in farmers.

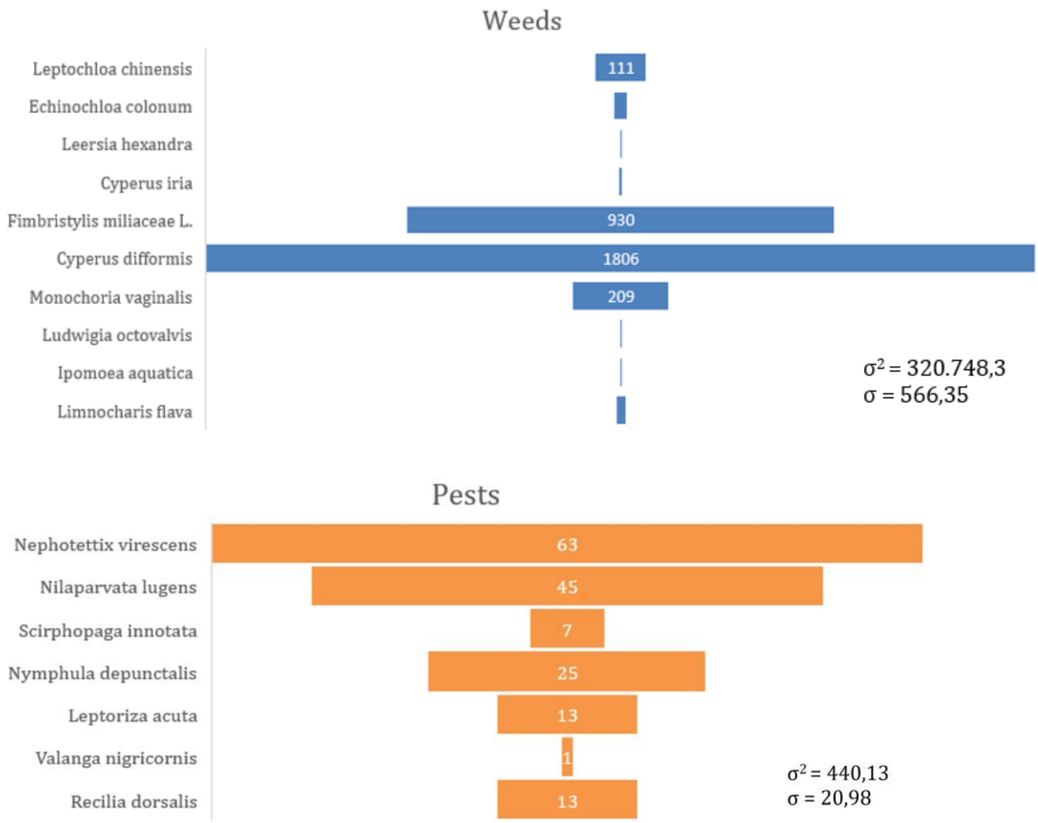
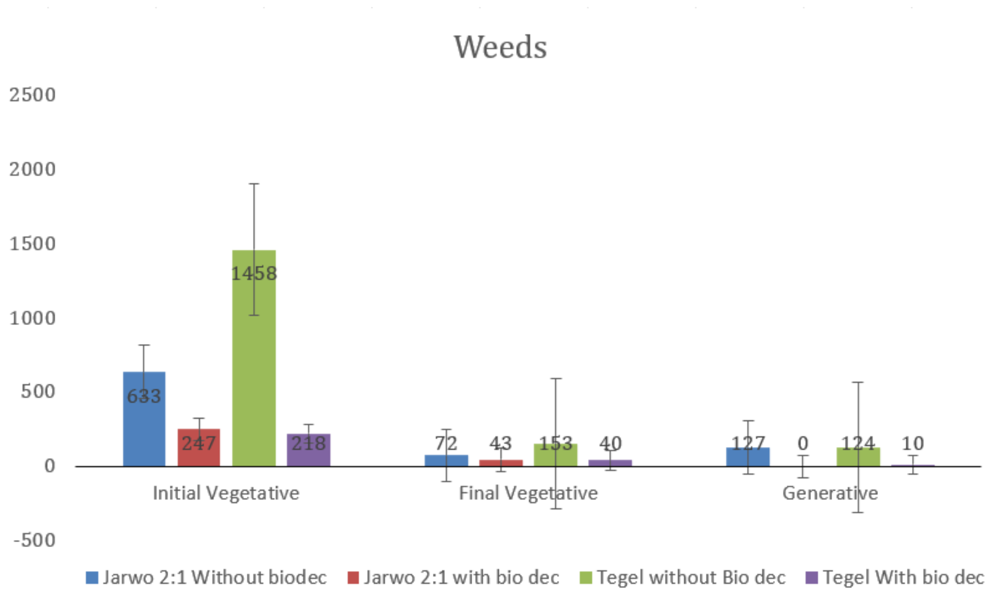



Figure 2. The total number of weeds and pests observed during the three phases of rice growth.

The initial vegetative phase had more pests and weeds than other phases. This is because planting conditions during the initial vegetative phase, particularly on terrain that frequently floods stimulate dormant weeds to germinate and propagate faster. In the meantime, bare land is favorable for pest banks, and planting rice becomes a new alternative host resulting in high pest populations in the early growing stage of rice. The biodecomposer treatment affected the pest population where the population was high at the initial vegetative phase and decreased markedly in the generative phase unlike plots treated without biodecomposer (Figure 3). It is probable that at the initial vegetative phase, the decomposer was still processing in the soil and had little impact on the pest population. At a later stage of rice growth, some pests became larvae or imago that were sensitive to fungi of *Trichoderma* sp., *Aspergillus* sp., and *Trametes* sp. contained in the biodecomposer; thus, biodecomposer became an entomopathogen that suppresses the development of larval and imago populations. Sanjaya et al. (2021) found two *Trichoderma sp*. species that were effective in killing 100% of *Crocidolomia binotalis* within 120 hours. Moreover, Poveda (2021) stated that *Trichoderma* controls insects through the mechanism of parasitism, producing secondary metabolites, insecticides, antifeedants, and repellent compounds. Previously, Singh et al. (2017) pointed out that *Trichoderma* strains attack several plant pathogens, promote plant growth and development, and are effective as biocontrol.



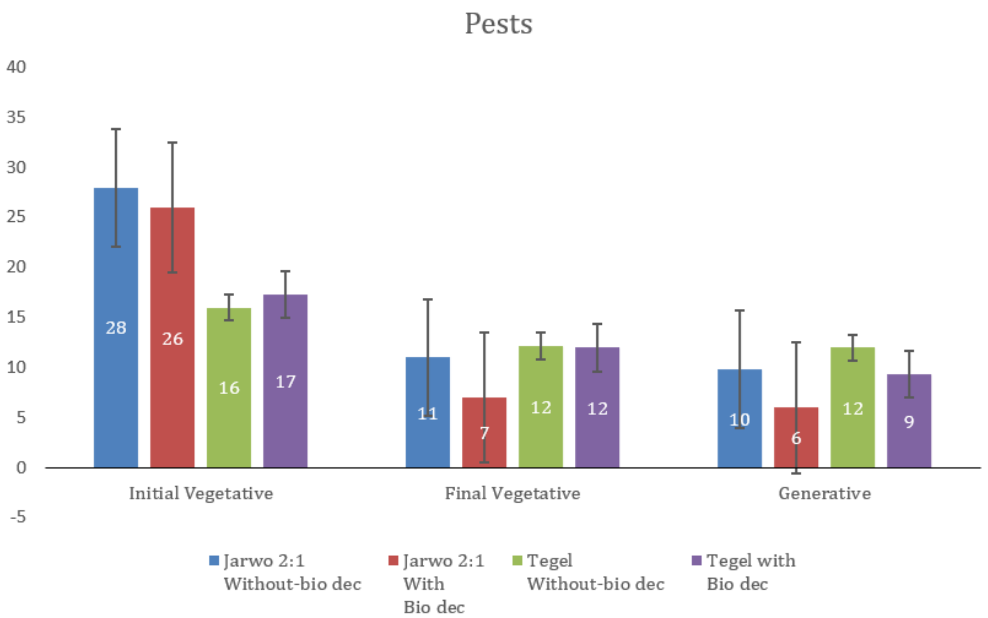




Figure 3. Comparison number of total individual weeds and pests observed for each treatment in three rice growth phases.

The Jarwo system (double-row planting system) showed lower weed and pest investment as compared to the Tegel (single-row) in the late vegetative and generative phases. The double-row planting system maximizes sun absorption as an energy source in the photosynthesis process so that the plant canopy develops optimally (Santosa et al., 2020). Optimal rice canopy stimulates better interspecific competition to weeds, on the other side, pests migrate to more susceptible hosts. The double-row planting system is also easier for farmers to manage fertilizers, weeding, and pest and disease control (Donggulo et al., 2017). Sutardi et al. (2023) stated that the increase in national rice production from 3 to 5.46 tons ha$^{-1}$ is influenced by planting systems from Tegel to Jarwo system.

## CONCLUSIONS

The use of a biodecomposer combined with a double-row planting system (Jarwo system) was effective in suppressing weeds by 61% and pests by 7%, while the single-row planting system (Tegel) was able to suppress weeds by up to 85% and pests by 6% as compared to without biodecomposer treatment. This means that biodecomposer application has a positive effect on both planting systems.

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