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Agroecosystem Management on Green Mustard Plants in Wetlands during Dry Season

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ABSTRACT

This research aimed to find a pattern of agroecosystem management that can increase arthropod diversity, production, and Return Cost Ratio (RCR) values in organic wetlands planted during the dry season. This research was set in Randomized Block Design (RAK) with seven treatments and five repetitions, namely: 1) Intercropping between green mustard and basil, with chicken manure and without *Bacillus thuringiensis*; 2) Intercropping between green mustard and basil with water hyacinth compost, and without *B. thuringiensis*; 3) intercropping between green mustard and leek, given water hyacinth compost, and without application *B. thuringiensis*; 4)Intercropping between green mustard and leek, given chicken manure, and without application *B. thuringiensis*; 5) Intercropping between green mustard and leek, given chicken manure, and given *B. thuringensis* application, doubled of recommended dosage; 6) Intercropping between green mustard and leek with chicken manure, and *B. thuringensis* application according to recommended dosage; 7) Monoculture of green mustard without organic fertilizer and without the application *B. thuringiensis*. From this research, it was concluded that the pattern of agroecosystem management of green mustard that can increase arthropod diversity in organic wetlands planted during dry season was the intercropping treatment between green mustard with basil, together with chicken manure and without *B. thuringiensis*. Meanwhile, the pattern of agroecosystem management of green mustard that can increase the production of green mustard and RCR value on the organic wetlands planted in the dry season was the intercropping treatment between green mustard with leek, together with chicken manure, and without *B. thuringiensis*.

Keywords: Intecropping, *B. thuringensis*, leek, arthropod diversity, chicken manure

INTRODUCTION

The mustard plant (*Brassica juncea* L.) is a type of plant leaf vegetables that has high economic value, including in the Cruciferai family. According to the history, mustard plants were originated from China and East Asia, they entered Indonesia during the XI century with its spreading areas especially in Cipanas and Lembang (Rukmana, 2007). The mustard plant is widely favored by Indonesians as a mix ingredient for processed foods and can be consumed raw, since it contains complete nutrition and fulfills the requirement to be part of nutritional needs of the community (Edi *et al.*, 2010).

Demand for mustard greens is increasing, in line with the increasing of population and the nutritional awareness. However, the production of mustard greens

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has not been sufficient for the needs and demands of the community due to several causes, one of them is the pest attacks.

Farmers control pest attacks using chemical pesticides (synthetic) and it is used very frequently, whether in average dose or high average concentration. Farmers believe that the usage of chemical pesticides is more practical in application and the results are more visible.

Based on the result of the survey in South Borneo, the frequency of chemical pesticide usage also occurred in the production center of the mustard in Banjarbaru, with the frequency of the usage ranged between 3-4 times per week. In fact, there are some farmers who use 2-3 kinds of mixed pesticides and use them simultaneously to control the pests.

The usage of synthetic pesticides to control the pest attacks will have negative impacts and can be overcome by managing agroecosystems that can make agroecosystem more resistant to pest explosion such as organic fertilizer application, intercropping, and bioinsecticide (*B. thuringiensis*) high selectivity and its effect as a GGnew toxin can be seen if ingested by insect pests, making it relatively safe for other insects that do not eat parts of plants containing *B. thuringiensis* poison (Novizan, 2002).

The goal of agroecosystem management is to create stability in the environment, sustainable yields, biologically managed soil fertility and pest population regulation through biodiversity and low input use (Altieri, 1999).

In South Borneo, mustard greens are planted on oranic soils of wetlands. The soils are formed by the accumulation of decaying wetlands' vegetation for hundred of years to form marshes. The mustard can be planted in the dry season and rain season.

To control pests of mustard plants and reduce the negative impact of chemical pesticide usage, it is necessary to design a pattern of agroecosystem management in full, in order to improve its stability by controlling pest arthropods at a non-harmful level by cultivating and using bioinsecticides that have little negative impact on agroecosystem.

This study aimed to find a pattern of agroecosystem management that can increase arthropod diversity, leaf production, and Return Cost Ratio (RCR) values of mustard planted during the dry season.

RESEARCH METHODS

This research was arranged to follow Randomized Block Design with seven treatments and five replications, which are:

1. Monoculture of green mustard without organic fertilizer and without application of *B. thuringensis* (P0).
2. Intercropping between green mustard and basil, with chicken manure without *B. thuringensis* (P1).
3. Intercropping between green mustard and basil, with water hyacinth compost, and without *B. thuringensis* application (P2).
4. Intercropping between green mustard and leek, with water hyacinth compost, and without *B. thuringensis* application (P3).
5. Intercropping between green mustard and leek, with chicken manure, and without *B. thuringensis* application (P4).
6. Intercropping between green mustard and leek, with chicken manure, and *B. thuringiensis* according to recommended dosage (P5).

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7. Intercropping between green mustard and leek, with chicken manure, and *B. thuringensis* at doubled the recommended dosage (P6).

Plot Preparation and Crop Planting

1. Sowing of the basil seeds
   Seeds of basil were sown in a sowing plot. One month old seedlings of basil were transferred to experimental plot according to treatment with spacing at 20 x 20 cm.
2. Sowing of green mustard seeds.
   Seeds of green mustard were sown in the sowing plot. After 15 days, the green mustard seeds were spreaded at the experimental plot with a spacing of 20 x 20 cm.
3. Sowing of spring onion
   The seeds of the leek are the 2,5 month old leek seeds, sown in the experimental plot according to treatment with spacing 20 x 20 cm.
4. Soil Processing
   The soil was processed by digging, until the soil turned loose and plot treatments were made with the size of plot 2 x 5 m with the distance between plots in group was 1 m.
5. Organic Fertilizer Application
   Provision of chicken manure and water hyacinth compost was given and evenly distributed 15 days prior to planting, each with a dose of 20 kg per plot.
6. Intercropping
   43 sowed seeds of leek and basil per row were planted in between the green mustard plants. One of experimental plot contained 4 rows (i.e., 172 plants). For all treatment in one plot, there were 215 seeds of green mustard.
7. Application of *B. thuringiensis*
   Application of *B. thuringiensis* is done twive (i.e., 7 days to 21 days after planting), by spaying 1 litre of water and containing 10 grams of B-tox per plot for treatment P5. One litre of water and with 20 gram B-tox was applied to treatmenr P6 plot.

There is have different harvest time of green mustard (25-30 days) and intercropping plant (basil and leeks, 2 month) so that the planting of intercropping plant earlier for one month and the followed by planting of green mustard. The object of observed for those treatments were the number and types of arthropods found in the experimental plots. The investigation was conducted for 7 days, 14 days and 21 days.

Observation

Arthropod was captured by fitfall traps. Five pitfall traps were placed diagonally at each plot for 24 hours.

a. Light trap was placed in the middle of each plot at night for 6 hours.
b. A yellow trap was set up near by the light trap during the day time for 6 hours.
c. The arthropods were captured as many as 10 times during the day time.

The captured arthropods were put inside the killing bottle for each plot, then grouped and calculated manually following the identification based on the identification keys describe by Boucek (1988).

The green mustard aged 25-30 days was harvested. Sub-sample from with 1 x 1 m of

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width were immediately weighed and recorded in kilogram unit. The basil and leek aged two months old were harvested as a whole and immediately weighed and recorded in kilogram unit.

Data Analyses

Data were than calculated to obtain the following values;

1. Index of Diversity (H') according to Shannon – Wiener (Southwood, 1978; Ludwig and Reynold, 1988)

$$H = -\sum_{i=1}^{Sobs} pi \ln pi$$

where:
pi : ∑ni/N
H : Shannon-Wiener Diversity Index
pi : The number of individuals of a species/total number of species
ni : Number of individual species i
N : Total number of individuals

2. Index of evenness (E) according Pilou (Ludwig and Reynold, 1988)

$$E = \frac{H}{\ln S}$$

where:
H = Index of diversity
S = The whole type

3. Index of species richness (R) according Margalef (Ludwig and Reynold, 1988)

$$R = \frac{S - 1}{\ln N}$$

where:
R = Index of species richness
S = Number of species
N = Number of individual species

4. Index of Domination (D) according Simpson (Southwood, 1978; Ludwig & Reynold, 1988)

$$D = \sum_{i=1}^{Sobs} (ni/N)^2$$

where:
D = Index of Domination
ni = Number of individuals per species
N = Number of individuals of all species

During the testing of the pattern of organic fertilizer treatment, intercropping plants and the use of *B. thuringiensis* were able to increase arthropod diversity, production and RCR value for each experimental plot was conducted using Group Randomized Block Design Variants.

The effect of treatment was determined from the F value and the mean value was differentiated by different standards using Duncan's Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

Influence of Organic Fertilizer, Intercropping and *B. thuringiensis* on Diversity Index, Richness Index, Evenness Index and Dominance Index in Wetlands During Dry Season

Based on the results of the research it was found that the types of organic fertilizer, intercropping plants and *B. thuringiensis* application had an effect on the diversity index on green mustard plantation.

The highest index value of biodiversity was found in the intercropping treatment between green mustard and basil, given

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chicken manure, without application of *B. thuringiensis* of 3.406 (P1) while the lowest diversity index value was obtained in monoculture treatment of green mustard without organic fertilizer, and without application of *B. thuringiensis* 2.537 (P0) (Table 1).

The highest index value of the species richness was obtained in the experimental plots treated intercropping green mustard with basil, given chicken manure without the application of *B. thuringiensis* of 7.888 (P1) and in the experimental plots given chicken manure, intercropping green mustard with leek without applied with *B. thuringiensis* of 7.754 (P4) whereas the lowest grade index value was found in experimental plots with intercropping of green mustard with leek, not chicken manure, and applied with *B. thuringiensis* according to recommended dose of 6.691 (P5) and in experimental plots treated intercropping green mustard with leek and hyacinth compost without *B. thuringiensis* of 6,774 (P3) (Table 1).

The highest values of the evenness index were found in the intercropping treatment between the green mustard and the basil which was given chicken manure, without the application of *B. thuringiensis* of 0.857 (P1) while the lowest species of evenness index was found in the treatment of monoculture of green mustard which were not given organic fertilizers, and without the application of *B. thuringiensis* 0.679 (P0) (Table 1).

The highest index value of dominance was found in intercropping treatment between green mustard and basil, which was given chicken manure, without application of *B. thuringiensis* of 0.021(P1) while the lowest dominance index value was obtained in monoculture treatment of green mustard which was not given organic fertilizer and without application with *B. thuringiensis* of 0.012 (P0) (Table 1)

Table 1. Average index values of arthropod diversity in green mustard plantations during the dry season in wetlands

No.	Treatment	Diversity Index	Richness Index	Evenness Index	Dominance Index
1.	P0	2.537 [a]	7.330 [c]	0.679 [a]	0.012 [a]
2.	P6	2.762[b]	7.105 [b]	0.730[b]	0.014[ab]
3.	P5	2.839[c]	6.691 [a]	0.759[c]	0.016[bc]
4.	P3	2.924[d]	6.774 [a]	0.773[d]	0.017[bcd]
5.	P4	3.067[e]	7.754 [d]	0.777[d]	0.019[cd]
6.	P2	3.258 [f]	7.320 [c]	0.838[e]	0.020[cd]
7.	P1	3.406 [g]	7.888[d]	0.857[f]	0.021[d]

Note: The means followed by the same letter were not significantly different based on the DMRT test at 5% significant level.

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The fact that combinations of organic fertilizer, intercropping, and *B. thuringiensis* treatments effected the diversity index, evenness index, richness index, and domination indexsuggested that the index of arthropod diversity is influenced by index of richness and evenness index. The higher the index of species richness and the evenness index were the higher the index of diversity. According to Ludwiq and Renolds (1988), species biodiversity consists of two components: the number of species in the community, often called species richness, and evenness of the species. Evenness shows the abundance of species scattered among many species. It has also been proven by Wibowo & Wulandari (2014) who examined the diversity of soil insects in different types of stands in a volcanic mountain education forest and its relation to the environmental variables. They found that the higher the index of species richness and the evenness index the higher the diversity index. According to Odum (1993) an ecosystem with high organism diversity entails the abundance of longer-formed food chains as well as more symbiosis-generating positive feedbacks that can reduce disturbances in ecosystems to achieve balanced ecosystems. This is also supported by the results of research (Morris et al., 2014) stating that the higher the diversity of crops the higher the index of arthropod diversity.

Influence of Organic Fertilizer, Intercroping Plant and *B. Thuringiensis* on Green Mustard Production and RCR on Wetland in the Dry Season

Based on the results of the research found that the types of organic fertilizer, intercropping plants and *B. thuringiensis* applications affect the production of green mustard in the plantation of green mustard.

The highest green mustard yield was found in the intercropping treatment between green mustard and leek, which were given chicken manure, without application of *B. thuringiensis* of 27.739 t ha^{-1} (P4) while the lowest green mustard yield was obtained in monoculture treatment of green mustard without organic fertilizer, and without application with *B. thuringiensis* of 14.235 t ha^{-1} (P0) (Table 2).

Table 2. The average production and RCR of green mustard on green mustard plantations that are planted on wetlands in the dry season

No.	Treatment	Production (ton ha^{-1})	RCR
1.	P0	14.235 [a]	1.434[a]
2.	P2	17.236 [b]	1.767[b]
3.	P5	17.595 [b]	1.782[b]
4.	P3	19.077 [b c]	2.356[c]
5.	P6	19.765 [c]	2.378[c]
6.	P1	23.246 [d]	3.035[d]
7.	P4	27.739 [e]	3.657[e]

Note: The means followed by the same letter were not significantly different based on the DMRT test at 5% significant level

The combination treatment of organic fertilizer, intercropping, and *B. thuringiensis* application influences the production of green mustard, and RCR. The intercropping treatment between green mustard and leaf-fed onions, and without the application of *B.*

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thuringiensis produced the highest yield of green mustard during the dry seasons on organic wetlands. The lowest yield of green mustard resulted from untreated monoculture treatment (no organic fertilizers, and without *B. thuringiensis* application).

Fertilizer is one source of nutrients in the soil that is highly influential in determining crop production. The addition of manure to the soil is necessary to meet the nutritional needs of crop, especially N, P, and K and the organic material to improve the soil physical conditions (Estiaty et al. (2006). Provision of chicken and goat manure give higher green weight per plant to mustard greens than the application of cow manure (Kurniawati, et al., 2017). This is because chicken manure has N (1,952%) higher than compost fertilizer (1,212%). N compound is needed for leaf growth from mustard plant. The growth of mustard greens plantation which is intercropped with leaf plant and not disturbed by leaf plant has a narrow canopy, compared to basil plants whose canopy protects mustard plants next to it. Of the six elements of macro nutrients, N, P, and K nutrients are required by green mustard (Primanto, 2004). The N element plays a role to stimulate vegetative growth of plants, P elements to encourage root growth and K elements necessary to strengthen the body of the plant. Tonfack et al., (2009) and Kidinda et al., (2015) stated that chicken manure is able to increase the availability of nutrients, especially the content of N in the soil. According to Amanullah et al., (2010) chemical composition of manure varies depending on its source, the animal's food, its age and its condition, storage and transport. Furthermore, according to Abbas, et al., (2011) the use of chicken manure gives a positive effect on the results and the quality of eggplant fruit. Similarly, Naim & Abker, (2016) stated that the use of chicken manure increases the growth and yield of okra plants in Sudan. This is also reinforced by Tiamiyu, et al. (2012) who states that organic fertilizer derived from poultry manure can increase the growth of both plant height and number of leaves of okra crops in Negeria

The highest RCR value was found in the intercropping treatment between green mustard and leek, without application with *B. thuringiensis*. This is due to the planting of the treated green mustard resulting in the highest yield. Additionally the leek has a high economic value compared with that of basil, so the intercropping treatment between green mustard and leek, treated with chicken manure, and without being applied with *B. thuringiensis* has the highest RCR value.

CONCLUSIONS

This research concluded that, the pattern of agroecosystem management of green mustard plantation that can increase arthropod diversity in organic wetlands planted in dry season was the intercropping treatment between green mustard with basil and chicken manure, without *B. thuringiensis*. Meanwhile, the pattern of the agroecosystem management that can increase the production of green mustard and RCR value on the organic wetlands planted in the dry season was the intercropping treatment between green mustard with leek and chicken manure, and without *B. thuringiensis.*

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