

Effect of rice husk biochar application to soil insect diversity on potato cultivation

A Meilin and R Rubiana

Jambi Assessment Institute for Agricultural Technology, Jalan Samarinda Paal Lima,
Kotabaru, Jambi 36128, Indonesia.
E-mail: araz_meilin@yahoo.com

Abstract. High intensity of disease infection and the intensive use of fertilizers and pesticides cause saturated fertilizer and pesticide to the land. Remediation using biochar rice husk is one of the technology to decrease fertilizer and pesticide residue. The diversity of soil insects can be used as bioindicators because of their existence depends on soil structure and condition. This study was aimed to study the diversity and structure communities of soil insect in potatoes on difference husk rice biochar application. The sampling of soil insects was done on potato farmer's land with four treatments i.e control (farmers' technique), trichokompos without biochar, trichokompos + biochar with dose 1 ton/ha, and trichokompos + biochar with dose 2 ton / ha. At each point a single pitfall trap was installed for two nights and then it was taken for identification. The results showed that biochar application had significant effect on the number of soil insect species ($P = 0.037$). The soil insect species composition pattern also showed significant differences between the four treatments ($R: 0.2306$, $P\text{value} = 0.001$). This mean that the application of biochar affects the number of insects species and plays a role in the formation of soil insect diversity beta patterns.

1. Introduction

The high incidence of leaf and stem diseases and the use of seedlings that have been infected by pathogens encourage potato farmers in Kerinci Jambi district to use fertilizers and pesticides on the recommended dosage [1]. For that matter, in the soil potato cultivation especially in Kayu Aro sub-district which is a vegetable center experiencing saturated fertilizer and pesticide. Excessive use of N-chemical fertilizers, damaging the environment and interfering with the absorption of other nutrients [2]. Pesticides applied to agricultural systems can be detected in air, surface and ground water, sediment, soil, vegetables, and to some extent in food [3]. Pesticides applied in soil for soil-borne pest control and pathogens will also produce accumulated residues and metabolites in soil at very high levels [4].

Various technologies are developed to deal with pollution of hazardous materials. Utilization of microorganisms (bacteria and fungi) is known to be a detoxifying agent of pesticides. Treatment of microbial and compost addition on pesticide contaminated soil resulted in decreasing percentage of chlorpyrifos, ethoprophos and carbofuran residues after 6 weeks of treatment were 86.35%; 83.91% and 82.32% [5]. Bioremediation with the use of compost is a good technique for solving environmental problems such as on contaminated soil. Microorganisms are very important part of the process [6]. Biochar from paper mill waste has proved beneficial to ferrous soil at a dose of 10 ton/ha which provides improvements to soil quality and affects plant growth [7].



Bioremediation technology with biochar utilizing agricultural waste has also been widely developed for the restoration of polluted soil contaminated by microbial activity as well as the enzymes it produces to transform harmful ingredients into non-hazardous materials. Agricultural wastes processed into biochar include corn cob, rice husk, coconut shell. Biochar is the result of degradation of organic matter in the absence of air that can be utilized to improve soil fertility and ecosystem services provided by soil organisms [8]. Biochar derived from rice husks showed higher ash content than biochar derived from tree branches, allowing interactions between organic and inorganic so as to decrease soil density, allowing the exchange of Al, dissolve Fe and increase porosity [9].

Improved land function can also affect the presence of soil insects because insects can show sensitivity to changes in their environment. Research shows that soils with high organic matter and good soil fertility show less abundance of herbivorous insects [10]. On the other hand, intensive farming practices with excessive use of synthetic fertilizers can lead to nutrient imbalances resulting in low pest resistance. The presence of soil insect populations may indicate a link to healthy or polluted farmland due to environmental regulation and nutrient availability allowing suitable living spaces for soil insects. So research on the diversity of insects can be used to find out more of the application role of these technologies in decreasing residual and increasing the production of potatoes indirectly.

This study was aimed to: 1) study the diversity of soil insects in potatoes in four different biochar rice husk treatments, 2) study the structure of the insect community.

2. Materials and Methods

The research was conducted in Sangir Tengah Village, Kayu Aro sub-district, Kerinci District, Jambi Province on farmer's land. From the previous observation, it is known that the land has an organosulfate residue. The research location is a potato centre. The study was conducted from April to August 2016.

Soil processing was done by making 20 bunds on peasant potato area of 1 ha. The technology of pesticide residual decrease studied consisted of four treatments: 1) Control (using the farmer's way that only with basic fertilizer before planting); 2) Trichokompos 10 tons / ha; 3) Trichokompos 10 tons / ha + Biochar / rice husk charcoal 1 ton / ha; 4) Trichokompos 10 ton / ha + Biochar / rice husk charcoal 2 ton / ha. Biochar was produced in a traditional way made from raw rice husks. Rice husks were inserted into a closed policator drum. At the bottom of the drum was given a fire. The husks were left to charcoal. Next the rice husk that has become charcoal, issued through the bottom door of the drum and cooled [11]. Trichokompos is an organic material composted by a decomposer of self-produced Trichoderma biological agents. Cattle manure, biochar rice husk, trichoderma mixed with a ratio of 400: 40: 1 stirred until blended and moistened with enough water then covered with black plastic / sack and incubation 7-10 days [12].

Each treatment was applied to 5 bunds before planting. Furthermore on each planting hole with a depth of 10 cm diameter 25 mm planted one seed potato local varieties Granola. Spacing used is 60 cm between rows and 30 cm between seeds in a single bundle. Harvest was done after the plant was 90-100 HST, with the criteria of stems and leaves had dried and potato tubers when rubbed with each other tuber skin was not released.

2.1. Sampling and insects identification

In each treatment was mounted 10 traps (pitfall trap) so that on each bundle there were 2 points of sampling. A glass trap with a diameter of 13 cm contained a 70% alcohol solution and a soapy liquid deposited 10 cm deep in the soil [13]. Traps were installed for the next two nights then were taken for identification [14].

The insect identification data was tabulated to the database in Microsoft Excel 2010 format. The views of the entire insects obtained were depicted in the species accumulation curve to estimate the existing insect population from the estimated value of S (observation) by randomized the number of species acquired at each sub-plot point of type of land use 50 times using the software EstimateS

version 9.1.0 [15]. To determine the diversity of insects that focus on species richness or the Shannon-Wiener Diversity Index was calculated using the equations [16].

$$H' = \sum_{i=1}^{\infty} (P_i \ln P_i) \quad (1)$$

H' = Shannon-wiener Diversity

P_i = proportion of insect species i (n_i) towards total of individual (N) ; (n_i/N)

The criteria used to interpret Shannon-Wiener's diversity are $H' < 1$ = Low Diversity; $1 < H' < 3$ = Medium Diversity; And $H' > 3$ = High Diversity [16].

The effect of treatment on the number of insect species (S) and the index of insect diversity (H') was analyzed using ANOVA [17]. Furthermore, to know the similarity of soil insect structure at different treatment was by ANOSIM test (Analysis of Similarity) to get the difference coefficient statistic value. The analysis was performed in the R program. The composition of insect species present in each treatment based on the Bray-Curtis index was made in a non-metric multidimensional scaling (NMDS) ordinance using multidimensional scaling (MDS) analysis [18]. The analysis was performed using R Statistic software: Vegan package [19-20]. The difference of composition based on the role of ants between types of land use is shown in the pie chart.

3. Results and Discussion

Species Accumulation Curves (SAC) in the form of S (observation) estimation values are obtained from data showing the total number of species from all sample points. The SAC showed an increase and the absence of asymptot sampling which means that the list of soil insect species on the land is incomplete or not yet optimal the number of collected soil insects species (Figure 1). However, for some taxa such as Arthropods especially in tropical habitats, asymptotes are highly unattainable [21]. So the curve is used to compare the species of soil insects obtained from the soil by different treatments.

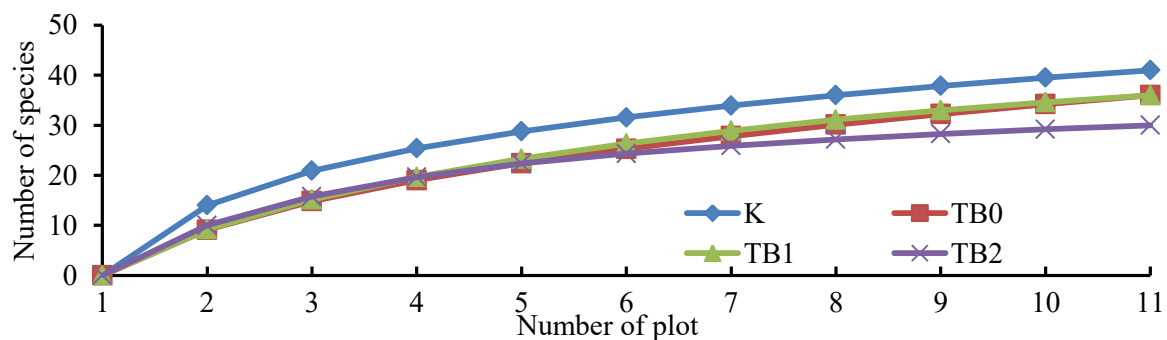


Figure 1. Soil accumulation curve accumulation at different treatments K = Control (farmer), TB0 = trichocompos only, TB1 = trichocompos + biochar 1 ton / ha; TB2 = trichokompos + biochar 2 ton / ha.

Based on the data obtained, there were 4,201 individuals belonging to 55 types of soil insects & the other Arthropods which belong to 11 orders (Table 1). Results of calculation of the highest number of species in the control and lowest land on the land with the giving of trichokompos + biochar 2 ton / ha. The provision of biochar significantly decreased the number of soil insect species in the field ($F_{3,34} = 2.739$, $P = 0.037$). The high number of species and index H' in the control area is due to the presence of herbivorous insects such as Hemiptera (Aphididae) and the other Athropods (Acarina) which are sheltered in weed plants. This is in line with Altieri and Nicholls's research on soils with high organic

materials generally exhibit fewer abundances than some herbivorous insects [10]. The decrease in herbivorous insects is caused by lower nitrogen content.

Table1. Diversity of insects on potato fields

Treatment ^a	Ordo	Number of species	Insect Diversity Index ^b	
			Abundance	H'
K	11	41	1077	2,54
TB0	10	36	876	1,97
TB1	11	37	1258	1,79
TB2	10	30	990	1,97
Total	11	55	4201	

^aResearch plot with the treatment

K = Control (farmer),

TB0 = only trichokompos,

B1 = trichokompos+biochar 1 ton/ha;

TB2 = trichokompos+biochar 2 ton/ha.

The results of the Shannon-Wiener (H') soil insect diversity index calculation on all four biochar treatments were moderate. Treatment of biochar did not affect H' index of diversity of insects ($F_{3,34} = 2.138$, $P = 0.114$). H' index was obtained with insect type parameters and the proportion of abundance of each species in a habitat so that the field with trichokompos + biochar 1 kg / ha treatment had the lowest H' index because the abundance of insects at this treatment was highest with the large number of Collembola findings. The increasing association of Collembola's abundance due to biochar was also performed in Reibe's research [22] which is further attributed to the morphological mechanism, biomass, the volume of roots of wheat crops. The results of NMDS analysis showed that different doses of biochar administration affected the structure of soil insect communities (ANOSIM statistic R: 0.2306, Significance: 0.001) (Figure 2).

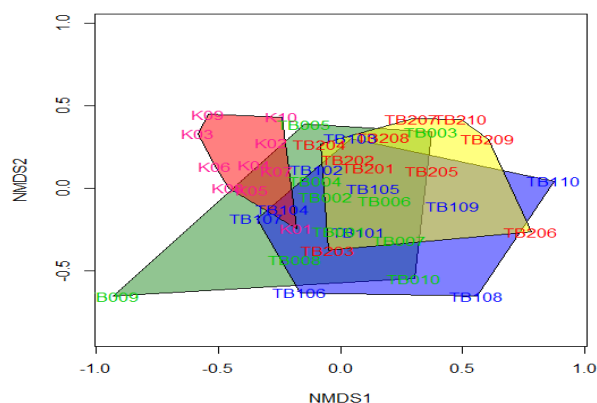


Figure 2. NMDS of insect composition based on Bray-Curtis inflation index in different treatments K = Control (farmer / pink field), TB0 = trichokompos only / green area, TB1 = trichokompos + biochar 1 ton / ha or colored field blue; TB2 = trichokompo + biochar 2 ton / ha or yellow field; The numbers (01 - 10) show the sample point as a repeat.

The formation of soil insect compositions provides more information than just the ratio of species. The composition of soil insects is indicated by the separation of plane between the treatment groups. It appears that the interplanes overlap, indicating that the insects in each treatment are similar in species.

The dimension of the control field has a field that is not too broad compared to other treatment dimensions because each sample point shows a high similarity. This is due to the discovery of lice (Aphididae) are abundant in the control field, while predators are found to specialize. A series of habitat characteristics may contribute to the residence preferences of most species of insects trapped in traps [23]. The preferred habitat of insects with detritivor role is on Trichokompos land of 10 tons / ha + Biochar / rice husk rice 1 ton / ha.

While ants (Hymenoptera: Formicidae), which is one of the cosmopolitan social insects group which is often used as bioindicator most found in Trichokompos land 10 ton / ha + Biochar / rice husk rice 2 ton / ha that is 6 point from 15 point of encounter. The family showed that densely fed biochar fields contain more diversity than controls. The ants belong to the genus Myrmicinae of small ants

such as Pheidole and large ants such as Tetraponera. Pheidole is known to be found in litter which is included in generalized myrmicinae group functions are cosmopolitan and sub-dominant ants occur in most habitats, have the ability to survive and quickly adapt to collect food sources.

On Trichokompos land of 10 ton / ha + Biochar / rice husk husk 0 ton / ha it appears that the NMDS field is wider. This is due to the discovery of the group of kutu-kutuan, spiders (Araneae), mites (Acarina) are varied because generally predators found are active predators foraging.

The results of the analysis of the types of insects found in different treatment sites are shown in Figure. The composition of insect species based on their role indicates differences between treatments. Insects with a particular role dominate on certain types of land use. In the field of trichokompos + biochar treatment of 1 ton / kg with trichokompos + biochar 2ton / kg area showed relatively few insect species when compared to the type of insects in the control field. The soil possesses fertile soil properties so that herbivorous insects are not found.

Herbivorous insects that dominate the field of observation sites were *Gryllotalpa hirsuta*, *Phyllophaga javana*, *Brachytrypes portentosus*, and ground worms (*Agrotis ipsilon*). These insects become pests, because they attack the stems and roots which are also reported as the cause of the low production of potatoes and are able to attack all the growing phases [24]. In addition to the control area, aphids that attack the plant by sucking leaf liquid were also found, therefore the attacked plant leaves appeared to be wrinkled and kinky. The abaxial surface of the leaves was silvery because the inside of the hollow leaves after the liquid is inhaled.

Herbivorous insects can be categorized as pests if they result in losses that exceed the economic threshold. However, farmers often do not want to take the risk, so often apply insecticides as soon as possible when they find some insects. Often also encountered, farmers have not been able to distinguish which insects are acting as pests or natural enemies that are important for pest control.

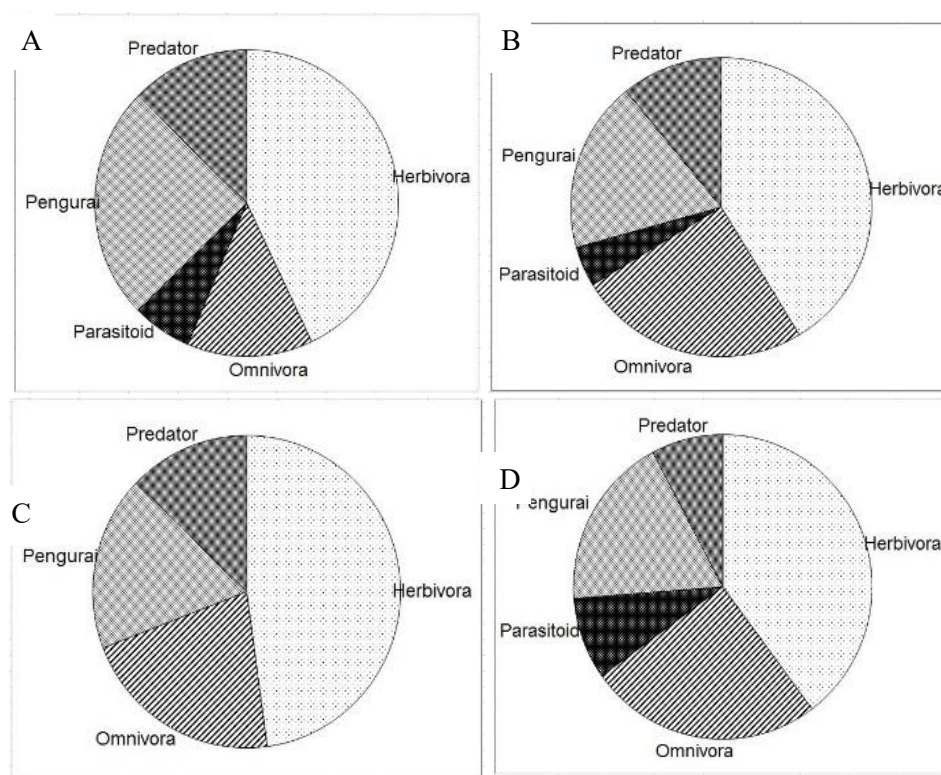


Figure 3. The role and composition of insects in four treatments (A) Controls; (B) Trichokompos 10 tons / ha; (C) Trichokompos 10 ton / ha + Biochar / rice husk charcoal 1 ton / ha; (D) Trichokompos 10 ton / ha + Biochar / rice husk charcoal 2 ton / ha.

Some fauna besides insects that are also found in the four differently treated fields belonging to the macrofauna group of soil (size > 2 mm) consist of milipeds, isopods, earthworms. The role of fauna besides insects is decomposition, carbon flow, nutrient redistribution, nutrient cycle, and soil structure formation. Earthworm biomass has been known to be a good bioindicator for detecting pH change, presence of organic horizon, soil moisture and humus quality.

In the land treated with Trichokompos 10 tons / ha + Biochar / rice husk charcoal 2 tons / ha of parasitoid and predator insects more than other treatment areas because the land is dominated by predators and omnivorous ants. Habitat transformation is very influential on ant behavior such as competitive interaction, avoidance of predators, and parasitism. The dominance of ant groups in a habitat indicates that the habitat is relatively more stable because it is associated with the presence of prey [25].

4. Conclusion

The application of rice husks biochar affected the number of soil insects. The higher rice husk biochar dosage was showed fewer abundances than some herbivorous insects species. The structure of insect community showed the composition of soil insects dominated by herbivorous insects species at control, and trichokompos + rice husk biochar treatments showed soil insect composition dominated by insects omnivorous, detritivore, parasitoid and predator role.

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