INNSPUB

Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print) 2222-3045 (Online)
Vol. 10, No. 4, p. 163-173, 2017
http://www.innspub.net

RESEARCH PAPER | OPEN ACCESS

Implementation of integrated pest management based on detrivore augmentation against soil arthropod's abundance and diversity in rice field

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Article published on April 30, 2017

Key words: IPM's tactic, Collembollan, Soil arthropod's, Rice, Agro-ecosystem

Abstract

Detrivore augmentation is a part of Integrated Pest Management (IPM) tactic based on local potential owned by farmers. Its main objective is to increase the abundance of decomposers organisms. Decomposers abundance is an indicator of the nutrient cycling availability. It also indicates the availability of alternative energy source that ensures the natural enemy populations. Augmentation efforts made through the addition of biomass include straw residue, *Azolla* sp., and organic fertilizers. Mutually with other IPM culture techniques applied, it can improve the abundance of soil arthropods by 9% during the dry season. Also there was an increasing by 15% at the wet season. Some taxa such as Araneae, Araneidae (orb-weaver spider) and Formicidae, which acts as a predator, have a significant increase in its population. A higher population was also observed in parasitic wasps, as well as in Collembola's and Diptera's: Chironomidae population, which acts as decomposers. In terms of the diversity index, there were no significant differences between sites (p = 0433; n = 48). However, the number of species, that is contributes to the community, is 1.4% higher in IPM site.

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Introduction

The limiting factor in rice production today is the reduced labor, then the declined quality of the water and the environment. The degradation of environment's quality contributes to the poor of soil nutrient. It also leads to the absence of durability of an agro-ecosystem towards pests and diseases and the climate change (Stuart, Ruth, Pame & Vithoonjit, 2017); (Horgan *et al.*, 2016). Input costs will increase as consequence and so reduces the efficiency of farming. Then, rice farming could be no longer profitable. In the end, it would be a threat to food sovereignty.

Implementation of integrated pest management (IPM) is a way to achieve an efficient agro-ecosystems. Efficiencies gained through the availability of a key factor in a rice agro-ecosystem. The key factor is pest population management mechanism, self-nutrient cycle, and the capability in facing problems due to environmental limiting factors. IPM principle is to maintain the quality of agro-ecosystems that is at least equivalent to the natural ecosystem. IPM's goal is lowering costs without sacrificing the quantity and quality of production (Stuart *et al.*, 2017).

It can be achieved by creating conditions that support biodiversity and activate the interactions between species (Horgan *et al.*, 2016). To get there, IPM focus on the enhancement of useful organisms, either by providing refugia or adding sources of supplementary food. The correct IPM implementation will provide sustainable sources of nutrients for useful insects. So the diversity of insect communities will be developed by the complexity of food webs (Nature, Crump, Haque, & Islam, 2016). IPM is a bridge between optimal products with the preservation of biodiversity in an agro-ecosystem. The concept of IPM is to understand and to plan an agro-ecosystem. Thus IPM program implementation is not universal but highly specific (Karuppuchamy & Venugopal, 2016).

The small scale rice cultivation in Indonesia is a supporting factor. From the ecological perspective, the small rice plots will enlarge disparities thereby reducing the risk of pest population explosion (Muniappan & Heinrichs, 2014). Besides, the traditional farmers in Indonesia have a variety of local wisdom in rice cultivation that is in line with the principles of IPM.

Meanwhile, the IPM implementation requires continuity as stated by (Muniappan & Heinrichs, 2014); (Karuppuchamy & Venugopal, 2016). IPM implementation needs the support of government policies and commitments (Oka, 1991). In fact, government policies in the agricultural sector are very dynamic. Therefore, research is needed to discover and to test the IPM tactic based on self-reliance and the utilization of farmer's local resources. A research conducted by Stuart *et al.* (2017), recommends several types of cultivation practices based on local resources and therefore reduce production costs. Among the land preparation, straw residues should not be burned but redistributed on the field. Tillage, soil reversal, and irrigation management applied to accelerate the decomposition of straw.

In this tactic, the decomposition process has a special attention. Decomposition occurs when there is a sufficient population of soil organisms. The decomposition process determines the occurrence of plant nutrients cycling. Maribie, Muturi, & Lagerl (2017) state that the reduced of abundance and diversity of soil organisms leads to the lack of ecosystem services. Moreover, some types of decomposers acts as a liaison between primary producers to the predator in the food web.

One type of the common decomposer is Collembolan. Collembolan has a variety of food preferences ranging from primary decomposers, secondary decomposers (eating fungi/bacteria decomposers), herbivore and carnivore (Maribie *et al.*, 2017); (Dudas, Menyhart, Gedeon, Ambrus & Toth, 2016). Straw residue on the surface of the land will increase soil moisture, provide shelter and nutrients for Collembolan. However, the Collembolan is sensitive to disturbances in the soil structure. The use of straw over the soil surface does not support its abundance as long as the tillage is done perfectly (Maribie *et al.*, 2017).

Also expressed by Palm, Blanco-Canqui, Declerck, Gatere & Grace (2013) that the straw as residue tends to produce a lower carbon stocks in comparison with the legume. Then, a treatment combination should be applied. Karuppuchamy & Venugopal (2016) said that the concept of IPM itself is a blend of various complementary and compatible tactics. Local resources that potentially used to fill the gap are the utilization of *Azolla* sp. and organic fertilizer from livestock waste. Livestock waste of herbivorous mammals provides nutrient concentrate, rich in bacteria, nitrogen, and carbon that supports various forms of detrivore community (Kearns & Stevenson, 2012). Meanwhile, *Azolla* sp. serves as bioremediation in contaminated water and at the same time able to provide nitrogen in the form of bio-fertilizer (Cary & Weerts, 1992). The effect of various cultivation tactics against the change of soil arthropod community needs to be recognized in order to achieves sustainability in an agricultural system (Maribie *et al.*, 2017). Therefore, this research is conducted. The aims of the research are to evaluate the IPM implementation that is supported by soil conservation tactic. The evaluation based on the presence of several indicators such as the abundance of different types of soil arthropods, the comparison of the number of species supporting the community and the value of diversity index.

Materials and methods

Study Site

The experiment was conducted in a rice field located in Watugede, at Singosari regency, Malang district, East Java. Treatment's site located at coordinates DMS Lat 7°54'S DMS Long 112°40'E. Site's size for each 28 x 36m, separated each other with another rice field.

The results of the soil analysis on both plots showed a low level of organic matter (from 3.59 to 3.73%), high phosphorus residue (12.61mg.kg^{-1}) and a neutral tends to be acidic soil pH (from 5.5 to 6.1). Data were taken at the dry season cultivation period between Juneuntil September 2015. The wet season data were taken during the period of February until June 2016.

Treatment

Treatment in this research contains of two cropping system which is the farmer's way (the conventional) and IPM. The comparison in detail of the two treatments is presented in Table 1. The variety of rice used in both site is Ciherang. Age of transplanting, tillage, water irrigation and weed control between two sites carried out by the same method.

Table1. Characteristics of Rice Field in Terms of Farming Practices (soil management, pesticide use, and fertilization).

Site	Management system	Spacing	Conserving soil management						Pesticide use & fertilization			
			Soil cover by fresh straw(range %)		Soil cover by Azolla(range %)		Manure application (kg.ha^{-1})		Pesticides : karbofuran[a)] (gr.ha^{-1}) difekonazol[b)](cc.ha^{-1})		Fertilizer apply (kg.ha^{-1})	
			Dry season	Wet season	Dry season	Wet season	Dry season	Wet season	Dry season	Wet season	Dry Season	Wet Season
1	Integrated	Jajarlegowo 40×25×12.5 cm	100	75	30-50	25 - 35	2000	1500	x	x	N=69 P=36 K=30	N=85 P=36 K=30
2	Conventional	square 25×25 cm	x	x	x	x	x	x	a:30; b:250	a: 30; b:500	N=91 P=45 K=45	N=91 P=45 K=45

Sampling Methode

Direct sampling and trapping were used to get soil arthropods data. Direct sampling produced an absolute population, that is could be converted into population per square meter. Meanwhile trapping produced relative population data. Weekly observation has been done since 7 days old plants. Last observation carried out 2 weeks before harvesting. Thus, it was conducted 12 times of observation in every cycle of cultivation.

- Relative data of soil arthropods obtained using pitfall traps. Totally, there are 5 pitfalls in every site. 4 pitfalls were laid systematically on a diagonal line of the site, while the other one is placed at the midpoint of the site. All pitfalls placed for 24 hours. The pitfall is a plastic cup with 500ml in volume and 15cm in diameter. It filled with 150ml NaOH solution 10% as a liquid trap. Trapped Insects were taken to the laboratory for identification with the help of a stereomicroscope and an arthropods classification manual handbook.

- Absolute data obtained from soil samples. The Soil sample was taken with a soil-corer measuring 15cm (depth) and 10cm (diameter). Each of the soil samples has 1177.5 cm^3in volume. There were three soil sample taken covering a $1m^2$plot. Five plots systematically placed in a site, near the pitfalls. Extraction of soil arthropods of each soil sample was performed using Berlesse Tullgren-Funnel. It is a cone with 25.4cm (10 inches) in diameter and 30cm in depth. The cone placed upside down. At the top, a wire gauze with 300 mesh hole size was attached. The base of the cone made hollow and we placed plastic tubes contain 10% alcohol solution as a medium container. The extraction process lasts for 24 hours. At the time of the extraction process, the insects will move to avoid a bulb lamp heat to the bottom of the funnel and dropped into the tube container.

- Daily temperature and relative humidity data obtained from Karangplo so Weather Observation Station with a distance of ± 8km from the study site.

Data analysis

Mann-Whitney test was used to analyze differences between the arthropod abundance per taxon. This kind of test is selected after the population data per taxon checked for the normality with the Shapiro-Wilk test (α = 0,05). Normality test resulted the value of p = $6.89.10^{-3}$ for dry season and p = $3.56{:}10^{-3}$ for wet season data (n = 480). The significance value gained with the help of R statistical software (R i386.3.2.2). We used Shannon-Wiener diversity index to measure the species diversity (Magurran, 2003).

Results and discussion

Total Abundance

Overall, amount of 6789 individual successfully collected from both sites. The results of identification show that they are belonging in 8 classes, 22 orders, and 97 morpho-species. 8 classes are arachnids, centipede, clitellate, collembolan, entognatha, gastropods, insects, rhabduran. 1,613 individuals were extracted by Berlesse funnel. 56% come from IPM site. While the conventional site gained 44%. If grouped by the season it was 23% of total IPM arthropods collected in the dry season and 33% in the wet season. The conventional site gained 16% in the dry season and 28% in the rainy season.

Population in the wet season tends higher than that is in the dry season. The same trend also occurred in the pitfall extraction. Amount of 5176 individuals gained, 68% is in IPM site, which is 24% from the dry season and 44% from the wet season. The remaining 32% is obtained from the conventional site with the composition 13% of the dry season and 19% of the wet season.

Boxplot graph (Fig. 1) shows the statistical data population on the overall 12 times observation. Data presented includes minimum and maximum values, the mean, the upper quartile and bottom quartile. Mean values is indicated by the line in the box. It appears that the average population in IPM site is higher than in conventional site for both seasons. The distribution of a population is determined by the size of the rectangular area. The wider box indicates wider fluctuation of a population between a sequence of observation.

The boxplots in IPM site appear larger than in conventional (Fig 1 & 2), except on Berlesse funnel in the wet season. We could said, that generally, the IPM site population is more dynamic, with sharper fluctuations. Otherwise, the stability of the interaction between populations in the ecosystem is usually marked with the smaller distribution across time (Durance *et al.*, 2016). In fact, we found that there was an overflow of population Collembola, Ants and Chironomidae.

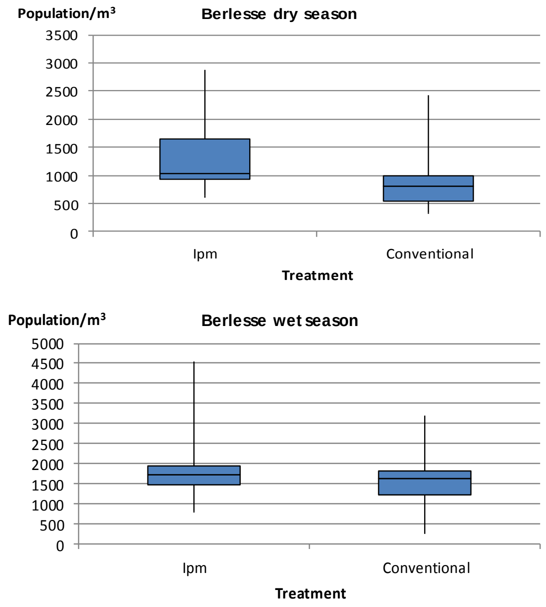


Fig. 1. Boxplot graph of Soil Arthropod Populations Extracted from Berlesse-funnel.

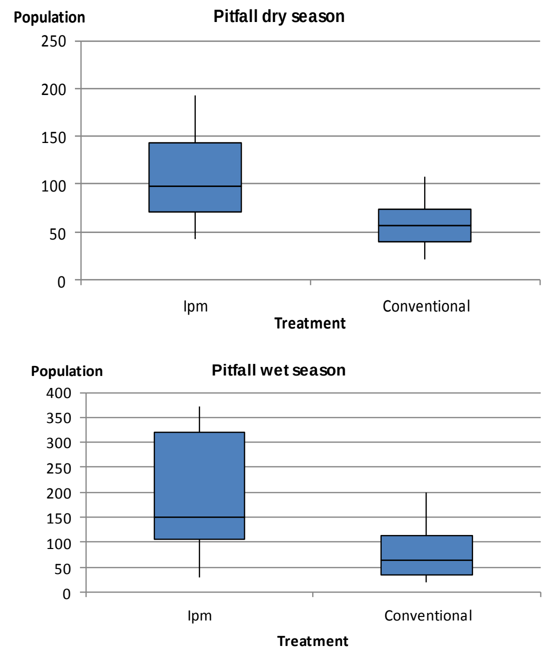


Fig. 2. Boxplot graph of Soil Arthropod Populations Extracted from Pitfall Trap.

IPM implementation has triggered an increasing in decomposers populations. Decomposers are primary consumers who gain benefit directly from the soil enrichment in IPM site. However, we analyzed that the population did not increase in a linear pattern. Population decline occurred at a particular observation time. Although it remains higher in number compared to those in conventional site. This could be an evident that a population self-control mechanism occurs. The declining decomposers population showed that they're being consumed by other species. That is the species which utilize as secondary consumers and make the decomposers as their nutritional source. Alam *et al.* (2016) declared that the correct IPM implementation will enhance ecosystem services and provide sustainable sources of nutrients for useful insects. The healthy agro-ecosystem will support the diversity of insect communities by maintaining the complexity of food webs. Base on that statement, we could see that IPM site has a healthier rice agro-ecosystem

It can be assumed that there was a dependent density interaction between the primary consumers and secondary consumers. Thus the population fluctuations in IPM land is not an indicator of instability. It's more likely as evident of the process towards a new stability point at a higher decomposer population. The stability will be gained if the practice applied along all cultivation season. It supports the statement of Karuppuchamy & Venugopal (2016) that gaining IPM's goals requires continuity of implementation.

Comparison of Population per Taxon

Based on data analyzed from soil samples, it appears that the population of arthropods in IPM site is higher than that is in conventional. But statistically there was no significant differences between two site ($p = 0.119$ in the dry season and p = 0397 in the wet season).

So, we divided the overall population into specific taxa according to their role in the food web. IPM has a significant effect toward the increasing of Collembolan, Formicidae and Diptera larvae population in the dry season (Table 2). While in the wet season observation, IPM has been increased spider's population (Araneaeand Araneida). We obtained the growth population also in parasitic wasp, Collembolan, and Formicidae.

The growth of collembolan population in IPM land can be predicted. Dudas *et al.*, (2016) revealed that the addition of biomass into the soil will built ideal environments for Collembolan. We found that there were three order, entomobryomorpha and poduromorpha which is an epigeic group that inhabits in the soil surface, and symplipleona which is a kind of 'in the ground'or endogeic. Collembolan. While the dominant collembolan found is order poduromorpha and entomobryomprpha (86% of the population of Collembola in IPM site and 81% in the conventional). Epigeic Collembolan leads to be decomposers and not be the roots-eating or herbivore collembolan (Dudas *et al.*, 2016).

Table 2. Results of the Mann-Whitney Test on Soil Arthropod Population Data from Pitfall Trap.

Taxa	dry season			wet season		
	Mean±SE		p-value	Mean±SE		p-value
	Ipm	Conventional	(10%)	Ipm	Conventional	(10%)
Acerentomata	0.583±0.499	0.000±0.000	0.317	0.000±0.000	0.083±0.083	0.317
Ampullarioidea	0.083±0.083	0.250±0.250	0.546	0.000±0.000	0.083±0.083	0.317
Araneae	9.417±0.307	12.50±3.609	0.602	4.083±0.949	1.417±0.712	**0.005***
Araneida	3.750±1.851	2.083±0.973	0.584	1.917±0.668	0.167±0.167	**0.005***
Coleopteran	6.500±0.821	5.250±1.194	0.246	2.583±0.773	2.417±0.543	0.930
Collembola	19.33±2.635	11.67±3.028	**0.003***	153.5±34.90	56.42±15.71	**0.032***
Dermaptera	0.167±0.167	0.000±0.000	0.317	0.083±0.083	0.000±0.000	0.317
Diplura	0.083±0.083	0.000±0.000	0.317	0.167±0.112	0.000±0.000	0.317
Diptera (Imago)	9.333±1.986	5.333±1.124	**0.097***	5.417±1.090	5.0±1.225	0.802
Diptera (Larva)	0.250±0.131	0.000±0.000	0.339	0.083±0.083	0.000±0.000	0.339
Ephemeroptera	0.000±0.000	0.000±0.000	1	0.000±0.000	0.000±0.000	1
Geophilomorpha	0.000±0.000	0.167±0.167	0.317	0.000±0.000	0.000±0.000	1
Haplotaxida	0.000±0.000	0.000±0.000	1	0.000±0.000	0.000±0.000	1
Hemiptera	1.823±0.548	2.083±1.340	0.266	0.667±0.310	0.583±0.229	0.738
Homoptera	2.917±1.579	0.333±0.225	0.053	1.500±0.657	1.500±0.609	0.535
HymenopteraFormicidae	7.000±1.829	3.000±1.273	**0.007***	10.82±6.421	7.250±3.456	0.098
Hymenoptra non Formicidae	1.333±1.157	1.083±0.583	0.977	2.333±0.595	0.917±0.288	**0.040***
Isopteran	0.000±0.000	0.000±0.000	1	0.000±0.000	0.000±0.000	1
Lepidoptera	0.417±0.149	0.333±0.142	0.680	0.417±0.193	0.417±0.149	0.988
Opiliones	0.000±0.000	0.000±0.000	0.317	0.000±0.000	0.000±0.000	1
Orthoptera	2.917±1.111	2.250±0.392	0.953	7.150±1.719	5.583±0.793	0.662

Remarks: The data show the number of mean ± standard error of each taxon. An asterisk (*) indicates significant difference between sites ($P < 0.05$).

The addition of organic fertilizer, *Azolla* sp., and straw mulch has the most obvious initial impact on the population collembolan either in the dry season or the wet season.

The population in the dry season was higher 66% and more than doubled in the wet season (172%). The addition of organic matter into the soil increase humidity and availability of food. Another benefit is to reduce the effects of extreme temperatures as stated by Gkisakis, Volakakis, Kollaros, Barberi, & Kabourakis (2016).

Temperature and relative humidity along observation tend to be higher in the wet season (Fig. 3 and 4). It is advantageous for *Collembola* species. As decomposers, collembola abundance can be an indicator of breakdown process of organic material into the nutrients compound that is available to plants. This leads to their ecosystem services (Maribie *et al.*, 2017).

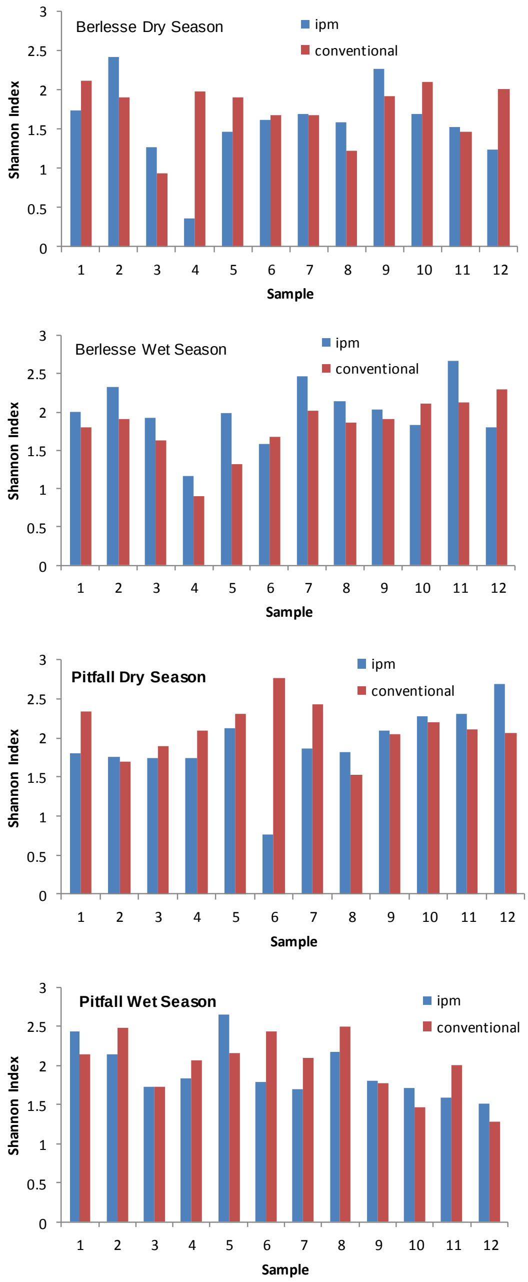
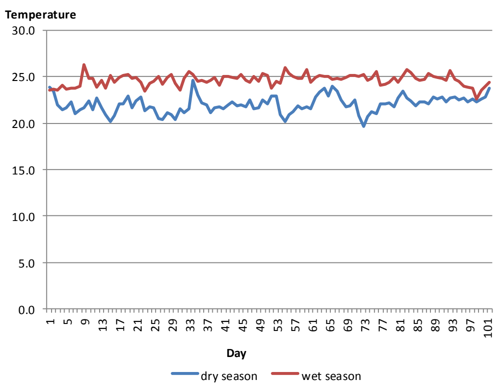


Fig. 3. The Diversity Index of Soil Arthropod Populations of The Two Seasons.



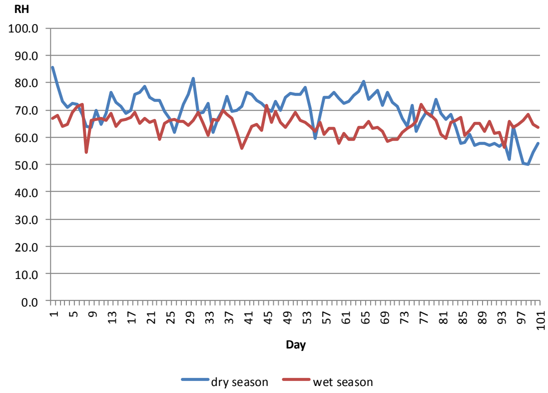


Fig. 4. The Result of Temperature (ºC) and Relative Humidity Measurement.

Family Formicidae was found in the area in four morpho-species which are *Solenopsis* sp., *Myrmica* sp., *Myrmicaer catogina* and *Monomorium* sp. Ants play a role as dominant organism in terrestrial habitat. They have a high sensitivity towards environmental factors and also high adaptability (Setiani, Akhmad Rizali, Moerfiah, Bandung, and Buchori, 2010).

At the beginning of the colonization, ants play a role in decomposition process of organic matter. Then, at a later stage, they have potential to dominate and shift their role as predators of other arthropods including decomposers species (Ganser, Denmead, Clough, Buchori, & Tscharntke, 2017).

Ants also identified as opportunist community. That is the community which utilizes one type of food that is abundant and can immediately switch to another type when the main feed thinned (Kearns & Stevenson, 2012).

This mechanism will run faster in agro-ecosystems with inorganic inputs dominancy. Low reserve of organic matter tends to be favorable for the invasive species population. As a result, some species of arthropods are eliminated and lowering the levels of diversity (Hasriyanty, Rizali, & Buchori, 2015).

Formicidae population increased as a result of the treatment in IPM site. Data from Berlesse-funnel (Table 3) show the population has increased four times compared to in the conventional in the dry season. Meanwhile in the wet season, the growth of population obtained only from pitfall data. The addition of organic matter in IPM is an augmentation effort for decomposer ant. Thus the higher population potentially followed by the availability of nutrient cycling mechanisms (Shukla, Singh, and Rastogi, 2016).

Table 3. Results of the Mann-Whitney Test on Soil Arthropod Population Data from Berlesse-funnel.

Taxa	Berlesse Dry Season			Berlesse Wet Season		
	Mean±SE		α-value (5%)	Mean±SE		α-value (5%)
	Ipm	Conventional		Ipm	Conventional	
Acerentomata	0.417±0.260	1.000±0.492	0.309	0.000±0.000	0.000±0.000	1
Ampullarioidea	0.250±0.250	1.917±1.917	0.406	0.000±0.000	0.000±0.000	1
Araneae	1.000±0.461	0.750±0.218	0.630	1.750±0.579	0.583±0.229	**0.045***
Araneida	0.083±0.083	0.167±0.112	0.558	0.167±0.112	0.167±0.112	1
Coleopteran	4.000±0.929	2.583±0.763	0.252	3.083±0.484	3.583±1.221	0.709
Collembola	8.750±0.219	5.583±1.125	0.221	17.33±3.013	14.75±4.060	0.615
Dermaptera	0.083±0.083	0.000±0.000	0.317	0.083±0.083	0.167±0.112	0.558
Diplura	0.250±0.250	0.000±0.000	0.317	0.000±0.000	0.083±0.083	0.317
Diptera Imago	4.750±1.088	1.917±0.811	**0.041***	3.167±1.236	2.167±0.777	0.502
Diptera Larva	0.583±0.313	0.583±0.313	1	0.000±0.000	0.000±0.000	1
Ephemeroptera	0.000±0.000	0.167±0.112	0.317	0.083±0.083	0.000±0.000	0.317
Geophilomorpha	0.583±0.260	0.167±0.112	0.162	0.000±0.000	0.000±0.000	1
Haplotaxida	2.000±0.577	1.417±0.434	0.429	0.833±0.345	1.167±0.747	0.609
Hemiptera	0.333±0.333	0.083±0.083	0.370	0.000±0.000	0.000±0.000	1
Homoptera	0.333±0.333	4.083±1.427	0.480	0.417±0.260	0.000±0.000	0.317
Hymenoptera: Formicidae	43.42±11.30	10.58±3.220	**0.039***	8.583±1.734	4.250±1.162	**0.042***
Hymenoptera non Formicidae	4.583±1.076	4.333±0.864	0.858	2.583±0.557	1.833±0.548	0.348
Isopteran	0.000±0.000	1.083±0.434	0.317	0.000±0.000	0.000±0.000	1
Lepidoptera	0.333±0.188	0.583±0.313	0.314	4.417±1.607	5.417±1.690	0.672
Opiliones	0.083±0.083	0.083±0.083	1	0.167±0.112	0.083±0.083	0.558
Orthoptera	0.417±0.913	0.083±0.083	0.137	0.250±0.179	0.417±0.193	0.534

Remarks: The data show the number of mean ± standard error of each taxon. An asterisk (*) indicates significant difference between sites ($P < 0.05$).

The growth population also obtained in parasitic wasp (Hymenoptera non-Formicidae) extracted from pitfall traps during the wet season. There were 7 groups of wasps which are Bethylidae, Braconidae, Chalcididae, Elasmidae, Mymaridae, Pteromalidae and Trichogrammatidae. A total of 22 individuals were found in the conventional site and 31 individuals in IPM. Generally, parasitoid found as egg parasitoid of rice stem borer.

Parasitoids have been found in IPM site since the first observation, whereas in conventional land began at the second observation. Parasitoid always found at every observation in IPM site. The peak populations obtained at the 5th and 8th observations (42 and 63 days after planting). If it is associated with the plant growth phase, it was time of vegetative growth and panicle formation phase. It is known that the phase is a susceptible phase to stem borer attack.

The combination of the food availability from the preferable rice varieties and the lack of environmental regulatory population function will promote the explosion of stem borer population (Hu *et al.*, 2014). Otherwise, sufficient parasitoid population in IPM site will provide the chances of self-regulation on pest population.

Diverse habitats not only affect the number of parasitoids to come, but also increases the degree of parasitism (Nugraha, Buchori, Nurmansyah, & Rizali, 2014). On the other hand Bear, Johnson, & Jones (2013) proposed the concept of the relationship between soil arthropods with a parasitoid. Arthropod soil from the root-eating group could potentially increase the production of secondary metabolites in plants. Secondary metabolites produced in response to the wounding of plant roots. The content of secondary metabolites in plants will be a residue when the plants are eaten by herbivorous arthropods.

Herbivorous arthropods residue in the body due to a mismatch results in poor growth nutrients. Parasitoids tend to avoid such kind of non-fit prey because it will decrease the quality and quantity of oviposit. In other words, prey abundance does not automatically increase the incidence of parasitism (Bear *et al.*, 2013).

Based on the concept above, the abundance of parasitoids in IPM site has indicated two things. The first, there is the potential for self- regulation toward major rice pest. Next, it shows the good quality relationship between soil arthropods function and the plant growth.

Both pitfall and Berlesse-funnel gained a growth population in Araneae data. as many as 21 individuals of Araneae extracted from IPM site and 7 individuals from conventional as many as 49 individuals from the IPM and 17 individuals from conventional were collected by Pitfall. The dominant species found are *Oxyopes* sp., *Tetragnatha* sp. Both of them are polyphag, acting as eggs and nymphs predators. Predation would happen if a predator hunt and at the same time the prey is available. The non-synchronization of two factors leads to predation failure. Drieu & Rusch (2017), reveal temperature also affect the predator's area determination where they in search of a prey. Warmer temperatures will reduce the area of movement. On the other hand, it will speed up the metabolism of nymphs into adult prey, thus it will shortening the chances of predation (Logan, Wolesensky, and Joern, 2006). Failure predation will reduce the quality of predator's life and impact on the decreasing in their population.

Temperatures are 2°C higher in the wet season (Fig. 4). The mean value of daily temperature during the dry season is 22.04°C and 24.65°C in the wet season. On the field we found, there was a decrease in Araneae population both in IPM (44%) and conventional site (85%). The same case obtained from the *Lycosa* sp (Araneida) population. Population decline 49% in IPM site, much lower than that in conventional (92%).

The rate of population decline in conventional site is two times more than that occurred in IPM site. This could be evident that IPM treatment able to act as a buffer for spiders predator community in the case of facing a rising temperature. Predator's community in IPM site potentially has a higher resistance. Therefore, this cultivation system can be recommended as a solution for the unpredictable climate change.

Diptera also showed a significant difference between treatment sites. Almost 85% of the dipteran identified as Chironomidae. In the food chain, Chironomidae primary act as decomposers and secondary, as a connector between producers and consumers. Larvae, pupae, and adult of Chironomidae are polyphagous. Larvae and pupae are on the top layer of mud sediment in the fields. It is the sections where there is often an accumulation of poisonous chemicals residue. Thus the Chironomidae's abundance could be a reflection of agro-ecosystem quality (Marchiori, Baumart, & Santos, 2012).

The existence of Chironomidae in IPM site has an even distribution in every observation at the dry season. Meanwhile, in the conventional site, there were no Chironomidae collected at 28th until 35th and at 70th observation. That could be related to the presence of residues of pesticides applied at 25th and 63rd days after transplanting. At the wet season, there was no significant difference. It was possibly due to the increasing potential of leaching toxins residues by rainwater.

Chironomidae reserve population in agro-ecosystems is important in rice fields as alternative nutrients for predators, especially at early planting. Therefore, It is necessary to develop cultivation techniques with minimal residues includes that has been done in the IPM site.

Diversity Index

The diversity index of Berlesse-funnel data in IPM site varies from 0.356 at 4th observation in the dry season to 2.670 at 11th of the wet season (Fig 3). It is classified as low to medium diversity based on the Shannon-Wiener description.

The result from data pitfall ranged from 0.765 at 6th observations in IPM site in the dry season and 2.767 at 5th observation in conventional land in the wet season. Overall, mean value of IPM site is 1.850 ± 0.065. Whereas in conventional 1.918 ± 0.056. Unpaired t-test has proved no significant difference between two sites (p= 0433).

The low value of the diversity index at a particular observation is not an indicator of less number of functional species in IPM site. But, it is due to the rising of dominance index as consequence of large number of decomposers species (Collembola), decomposers-predator (Formicidae) and parasitic wasp (Hymenoptera non-Formicidae). It is supported by the fact that the number of species found in IPM site (74 morpho-species) was higher than in conventional fields (73 morpho-species).

Conclusion

IPM has a positive influence on soil arthropod populations in the dry season and in the wet season. The population increased by 13%in average. Several taxa have directly affected by the applied IPM. Include predator (Araneae, Araneidae, and Formicidae), decomposers (Collembola, Diptera: Chironomidae) and the parasitic wasp (Bethylidae, Braconidae, Chalcididae, Elasmidae, Mymaridae, Pteromalidae and Trichogrammatidae). This reflects an increase in availability of nutrient cycling and population control service.

Recommendation

Furthermore, the implementation of IPM should be carried out continuously in order to achieve the more stable agro-ecosystems and improve the efficiency of rice farming.

Acknowledgement

This research was supported by Board of Extension and Human Resources of The Ministry of Agriculture Republic indonesia. We are grateful to STPP Malang staff Joko Gagung, Didik Darmanto, Sunarto, Kasiadi and Rumakyah for their field assistance. We deeply appreciate Dr. Akhmad Rizali who helped us with the insight to present the data analysis.

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