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The Impact of Integreated Pest Management (IPM) Application on Soil Diversity of Fauna and Disease Intensity on Potato Farms

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Abstract.

Potatoes are a vegetable source of carbohydrates so they have great potential as an alternative staple food. Pest and disease disorders are the main obstacles. The purpose of this study was to determine differences in pest population levels and disease attacks in potato crops with application IPM and conventional systems. The study was conducted in Garut Regency and in West Bandung which was conducted from July 2015 - March 2016. In each location the compared between IPM application treatment and conventional treatment (local farmers' way) was compared. The treatment tested are as follows: (1). T1: IPM system that is : plot with the application of IPM technology produced by IVEGRI. (2). T2 : IVEGRI IPM system + use of silver plastic mulch cover. (3). The conventional treatment system. The seeds used are Granola tuber let varieties with a size of 5-7gram. the results of the study show that : (1). The IPM treatment with use of silver mulch increase the benefits of applying IPM. Plant growth and yields are higher than conventional methods. (2). The IPM treatment with or without mulch provides a better environment for the development of soil fauna (3). The use of selective and minimal pesticides in IPM treatment increases the population of Collembola, Acarina and Diplura soil fauna. (4). Attacks of airborne diseases (late blight and early blight) are not infulenced by the treatment but by the season.

Keywords : Solanum tuberosum L., IPM (Integrated Pest Management), Soil Fauna

1. Introduction

Potatoes are a vegetable source of carbohydrates so they have great potential as an alternative staple food. The economic value is high for both the domestic and export markets. The average potato production in Indonesia in 2017 is around 1,164,738 tons. Whereas in 2016 around 1,213,038 tons, there was a decrease of around 3.98%. Likewise, the productivity of potatoes in Indonesia in 2017 was around 15.40 tons / ha and in 2016 around 18.25 tons / ha, down around 15.62%. But the harvested area in 2017 was around 75,611 ha and in 2016 around 66,450 ha, there was an increase in harvested area of 13.79%. Many obstacles are faced in the cultivation of potatoes to obtain high yields, clean and economical. Pest and disease disorders are the main obstacles. The main pests and diseases that attack on potato plants are leaf borers and potato tubers (*Phtheromaea operculella*), Thrips, aphids, leaf rot, wilting,

viruses and nematodes and leafminer pests (*Liriomyza huidobrensis*). Loss of results due to pests and diseases above have been widely reported, including due to leaf and tuber borer (*Phthorimaea opercuella*) reaching 36% - 100% (Setiawati and Tobing, 1996), due to leafminer pests can reach 67.7% - 87% (Min Kwon et al., 2017; Walyson *et al*., 2019; Mujica et al., 2013), due to leaf rot *Phytophtora infestans* (Mont.) De Bary 5% - 98.6% (Rakoton indraina et al., 2012), withering bacteria (*Ralstonia solanacearum*) 33% - 90% (Karim et al., 2018), complex viruses 24% - 82% (Damayanti and Kartika, 2015), nematodes 25% (Youssef, 2013). To overcome the problem of pests and diseases of potato crops, farmers generally use pesticides that tend to be excessive and unwise, so that the impact does not only occur in residual products but also environmental degradation and surrounding biological resources.

The concept of integrated pest control implements the use of pesticides truly wisely, most recently used. The use of natural enemies and other non-chemical controls to control pests and diseases is preferred, in order to obtain the quality of healthy potato products without disturbing the quality of the biotic and abiotic environment. Soil fauna is one that is influenced by biotic and abiotic factors because it can determine the population of fauna that live in a habitat. Fauna composition can change due to the influence of changes in vegetation. Soil fauna plays an important role in the decomposition of organic minerals and can determine the cycle of soil organic minerals and can accelerate the supply of nutrients and sources of soil organic matter. The groups of soil fauna that have the highest density and abundance in the soil ecosystem are Arthopoda including Insect, Arachnida, and Myriapoda. The most common insect group was collembola, whereas from the Arachnida group the most common was Acarina.

The development of potato cultivation is a promising business and will continue, so we need a way to manage pest and disease that are effective, safe and environmentally friendly. The adoption of IPM that promises healthy products and a clean environment needs to be promoted and more popularized with evidence of positive impacts better than conventional methods. The purpose of this study was to determine differences in the level of the populations of soil fauna and the intensity of disease in potato crops with application IPM and conventional systems.

2. Material and Methods

The study was conducted in two locations are Garut Regency (Cikajang) and in West Bandung Regency (Lembang) conducted from July 2015 - March 2016. In the experiment in each location, two treatments were compared to applying IPM and one conventional treatment (the way of local farmers) as Control. The treatments tested are as follows:

1. T1 treatment: IPM system, namely: experimental plot with the application of IPM technology produced by the Indonesian Vegetable Research Institute (IVEGRI)
2. T2 treatment: IVEGRI IPM system + use of silver plastic mulch cover.
3. The conventional system treatment is the experimental plot which is treated with the application of a local potato farming system conducted by large / advanced farmers. The conventional treatment is taken with the consideration that the most

dominant impact of conventional farming comes from the most extensive area of potato planting, which is owned by advanced farmers.

The seeds used are Granola varieties derived from tissue culture with size 5-7gram (tuber let). The type and time of application of fertilizer and the use of pesticides as well as other methods of cultivation from each treatment can be seen in (Appendix). The design uses a paired plot without repetition. For the sake of observation and statistical analysis, each main treatment is divided into 6 parts as repetitions to limit observation. Each treatment plot is 500 m2 so that the land area in each location of the three potato pest control treatments is ± 1,500 m2. The treatment using Randomized Group Design and the difference in the average treatment was tested with Multiple Distance Test Duncan at a level of 5%.

Implementation:

1. IPM plot both T1 and T2 is done by researchers.
2. Conventional plots are taken from the land worked by local farmers. From a large expanse of potato plantations, a 500 m^2 spread was taken. Conventional treatment plots are managed by potato farmers themselves. Planting, weeding, spraying of pesticides and their types and others independently (independent) without the burden that the research is being carried out in the plots.
3. Matters relating to the collection of research data in all the observed plots (T1, T2 and Conventional treatment) are done by the researcher.
4. Observations on all plots are the same for: plant height, soil fauna population, incidence / intensity of pest-disease attacks, crop yields and tuber quality.
5. To calculate the soil fauna carried out as follows: in each test plot installed "Pitfall" (a tool to capture soil fauna that is on the surface of the soil)
6. To capture fauna in the soil as follows: soil samples are taken as deep as 20 cm using a ground drill. Then the soil put into the "Barlate Tool Green" tool for 4 days. Existing fauna will float and counted

a. Plant Growth

The seeds used come from tissue culture with a size of ± 5-7 grams (tuber let). Plant growth data can be seen in (table 1).

Table 1. Effects of various pest control methods on potato plant height in Garut and Lembang (cm).

Treatment	Garut		Lembang	
	35 Dap	56 Dap	35 Dap	56 Dap
1. IPM	19,77 a	22,60 b	13,40 a	19,83 b
2. IPM + mulch	20,23 a	28,53 a	13,67 a	29,20 a
3. Conventional	18,53 a	19,73 c	10,77 a	26,03 a

Note: The average number followed by the same letter in each column shows no significant difference in UJB Duncan's level of 5%.

- *Dap = Day after planting*

The bulbs used are small, so the shoots that come out are only 1-2 stems, so to measure growth taken only plant height. The IPM and IPM + mulch treatments are all the same unless there is an additional black silver plastic mulch. It seems clear that mulch on potato plants has a better effect on plant growth, which is the highest compared to other treatments both in Garut and in Lembang. While conventional ones are no better than IPM, except in Lembang.

b. Soil Fauna Population

Soil fauna populations appear to be affected by potato cultivation. Data on soil fauna population observed from the ground and the surface can be seen in (Table 2 - 4). The soil fauna population observed from the soil sample that the composition is more stable. Generally the population in conventional aquaculture treatments is lower than IPM. Whereas in the IPM treatment the addition of silver plastic mulch inputs turned out to be able to increase the number of existing soil fauna populations of the cumulative Collembola, Acarina and Diplura species both in Garut and Lembang. The method of taking samples for observation also has an effect on the amount. The amount of soil surface catches are higher than in the soil catches. It seems that the soil fauna does not always settle in the soil, but there are active periods roaming the surface.

Table 2. Effects of various pest control methods on potatoes on Collembola soil fauna populations in Garut and Lembang

Treatment	Garut on observation to ….			Lembang on observation to ….		
	30 Dap	51 Dap	72 Dap	30 Dap	51 Dap	72 Dap
In the Ground						
1. IPM	6 a	26 a	8 ab	22 a	20 a	24 a
2. IPM + mulch	2 a	16 b	16 a	28 a	34 a	20 a
3. Conventional	2 a	4 ab	2 b	14 a	18 a	24 a
At Ground Level						
1. IPM	120 a	1.300 a	160 ab	748 ab	560 ab	480 b
2. IPM + mulch	52 b	672 ab	352 a	952 a	1.088 a	400 ab
3. Conventional	72 ab	56 b	12 b	280 b	360 b	624 a

Note: The average number followed by the same letter in each column shows no significant difference in UJB Duncan's level of 5%. Data analysis between data originating from the ground and data originating from the surface is carried out separately.

- *Dap = Day after planting*

Table 3. Effects of various pest control methods on potatoes on the Acarina soil fauna population in Garut and Lembang

Treatment	Garut on observation to ….			Lembang on observation to ….		
	30 Dap	51 Dap	72 Dap[	30 Dap	51 Dap	72 Dap
In the Ground						
1. IPM	2 a	10 b	2 a	0	8 a	0
2. IPM + mulch	2 a	10 a	10 a	0	6 a	0
3. Conventional	0 a	2 a	2 a	0	2 a	0
At Ground Level						
1. IPM	2 b	200 a	8 ab	0 b	48 a	0 a
2. IPM + mulch	16 a	20 ab	60 a	0 b	32 ab	0 a
3. Conventional	4 ab	8 b	2 b	6 a	4 b	0 a

Note: The average number followed by the same letter in each column shows no significant difference in UJB Duncan's level of 5%. Data analysis between data originating from the ground and data originating from the surface is carried out separately.

- *Dap = Day after planting*

IPM treatment again shows that the use of pesticides that are selective and minimally increases the population of soil fauna both Collembola, Acarina, and Diplura. The same thing happened in onion plants, that the population of soil fauna in IPM treatment using insecticides was slightly higher **(Setiawati, 2000).**

However, the addition of silver plastic mulch inputs to Acarina inhibits movement on the ground surface. Observations on soil fauna were also carried out on land planted with cabbage, the results showed that the most dominant fauna in cabbage plantations in Lembang was Collembola (72.92%), Diplura (21.67%) and Acarina (5.41%). Overall, it can be seen that the application of IPM conception can

increase the population of soil fauna in the soil by 58.0% and the surface surface by 58.34%, when compared with conventional treatments. IPM can increase the population of soil fauna by 70.97% and 113.39% at the surface when compared with conventional treatment **(Setiawati et al., 2000).**

Table 4. Effects of various pest control methods on potatoes on the fauna population of Diplura in Garut and Lembang

Treatment	Garut on observation to ….			Lembang on observation to ….		
	30 Dap	51 Dap	72 Dap	30 Dap	51 Dap	72 Dap
In the Ground						
1. IPM	2 a	6 a	12 a	10 a	14 a	6 a
2. IPM + mulch	10 a	8 a	12 a	6 a	12 a	2 a
3. Conventional	6 a	4 a	2 a	0 a	10 a	2 a
At Ground Level						
1. IPM	28 ab	168 a	a72 ab	220 a	196 ab	32 a
2. IPM + mulch	100 a	112 ab	120 a	132 ab	261 a	4 b
3. Conventional	12 a	32 b	16 b	12 b	100 b	12 b

Note: The average number followed by the same letter in each column shows no significant difference in UJB Duncan's level of 5%. Data analysis between data originating from the ground and data originating from the surface is carried out separately.

- *Dap = Day after planting*

c. Potato Disease

The most dominant disease according to the season that occurs, during the ordeal. The condition of potato disease in Garut and Lembang can be seen in (Table 5).

Table 5. Effects of various methods of controlling pests on the intensity of Late blight disease and Early blight on potatoes at the age of 56-68 days after planting (HST).

Treatment	Garut		Lembang	
	Late blight	early blight	Late blight	early blight
1. IPM	4,67 a	0,00 a	36,33 a	- *)
2. IPM + mulch	6,00 a	1,33 a	24,00 a	-
3. Conventional	8,00 a	4,67 a	36,67 a	-

*Remarks: *) = early blight are not found in Lembang*

- The average number followed by the same letter in each column shows no difference evident at UJB Duncan at the 5% level.

Late blight (*Phythophtora infestan*) and early blight (*Alternaria solani*) are airborne pathogens which are certainly not affected by treatments on the soil. The results of the statistical analysis were not significantly different between the treatment and the amount. However, there is a tendency that the intensity of these two diseases in the IPM + mulch treatment is the lowest. At the time of the research in Lembang there was no alternaria (early blight) attack found. The high incidence of leaf rot in Lembang due to high rainfall and humid conditions, where such conditions are suitable for the development of leaf rot disease as stated **(Rahayu et al., 2015)**, that in the months where the air temperature is high, for example in May to August the infestation of dry spot disease is more dominant than leaf rot disease.

d. Yields

The yield per plot between the two locations is impossible to compare, because in Lembang the potatoes are harvested earlier because the plants are destroyed by leaf rot. The harvest data is balanced by taking 10 sample plants. Statistically IPM treatment has no effect on tuber yield compared to conventional methods. In Garut the yield quantity is higher while in Lembang it is lower. However, IPM added with

silver plastic mulch was able to increase yields both in numbers (2.5 times conventional systems and 2 times IPM systems), and weight (10 times that of conventional systems and 7 times that of IPM systems) and were significantly different from other treatments. Similar crop yields occur in the Lembang area during the rainy season (Table 6).

Table 6. Effects of various pest control methods on potato crops on yields per 10 sample plants in Garut and Lembang.

Treatment	Garut		Lembang	
	Amount	Weight (kg)	Amount	Weight (kg)
1. IPM	68 a	1.748 a	92 a	1.360 a
2. IPM + mulch	135 b	7.674 b	200 b	3.870 b
3. Conventional	49 a	764 a	106 a	1.560 a

Remarks : The average number followed by the same letter in each column shows no difference evident at UJB Duncan at the 5% level.

The spread of potato tubers by size shifts towards smaller sizes (<40 g). The average size of large tubers (> 40 g) from each treatment in Garut is 20% and 17% in Lembang. For the best treatment Garut is PHT + mulch where the percentage of tubers with the highest size. This situation is different from the rainy season (in Lembang), where the percentage of tubers with a size> 40 g is the lowest. The distribution of the tuber size is more to the small size in Lembang because the harvested plants are not yet old due to high leaf rot disease. The distribution of bulbs from each treatment in the dry season (Garut) and rainy season (Lembang) can be seen in (Figures 1 and 2).

Figure 1. Distribution of Potato Tuber Size from Various Ways of Control Pest and Disease in Garut

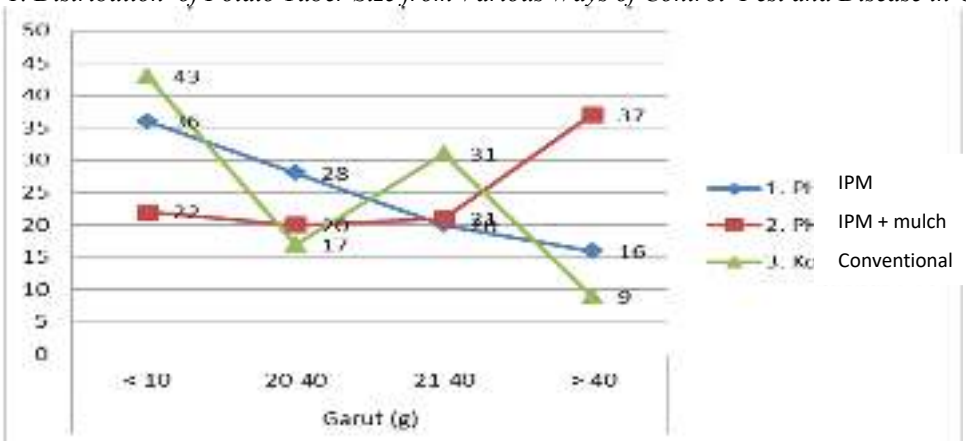
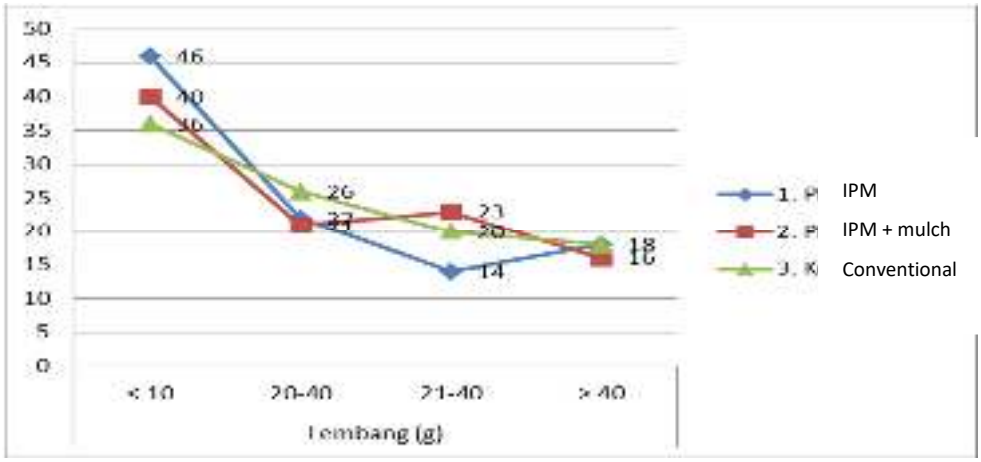


Figure 2. Distribution of Potato Tuber Size from Various Ways of Control Pest and Disease in Lembang



3. Conclusion

(1). The IPM treatment with use of silver mulch increase the benefits of applying IPM. Plant growth and yields are higher than conventional methods.

(2). The IPM treatment with or without mulch provides a better environment for the development of soil fauna

(3). The use of selective and minimal pesticides in IPM treatment increases the population of Collembola, Acarina and Diplura soil fauna.

(4). Attacks of airborne diseases (late blight and early blight) are not infulenced by the treatment but by the season.

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Appendix 1. IPM component treatment assemblies tested in Garut and Lembang

Components of Cultivation	IPM Balitsa	IPM Balitsa + Mulch	Garut Farmers	Lembang Farmers
1. Seed	Granola	Granola	Granola	Granla
2. Fertilizer per ha : - Basic - Artificial	 - Chicken 10 ton - Twice giving 1). ½ Urea+ZA+KCl)+SP- 36 planting time 2). ½ Urea+ZA+KCl)+SP- 36 planting time	 - Chicken 10 ton - Twice giving 1). ½ Urea+ZA+KCl)+SP- 36 planting time 2). ½ Urea+ZA+KCl)+SP- 36 planting time	 - Cow 30 ton - Once giving at planting time	 - Horse 30 ton - Once giving at planting time (Urea, ZA, Kl dan TSP)
3. Planting space	30 x 60 cm, double row	30 x 80 cm, double row	30 x 80 cm, single row	30 x 80 cm, single row
4. Soil cover	-	Silver plastic mulch	-	-
5. Setting trap : - Afid - Tuber borer - Leaf cutter	 -Not installed -Not installed - Yellow tie	 -Not installed -Not installed -Yellow tie	 -Not installed -Not installed -Not installed	 -Not installed -Not installed -Not installed
6. Observation :	Once a week	Once a week	Once a week	Once a week
7. Pesticides : - Application time : - Types of active ingredients of pesticides:: Interval :	- 41 days after planting 1. Mankozeb, Mefendoksam 2. Mankozeb 3. Abamektin 4. Deltametrin 5. Imidaclorprid 6. Karbofuran Once a week	- 39 days after planting 1. Mankozeb, Mefendoksam 2. Mankozeb 3. Abamektin 4. Deltametrin 5. Imidaclorprid 6. Karbofuran Once a week	- 43 days after planting 1. Mankozeb, Mefendoksam 2. Mankozeb 3. Abamektin 4. Deltametrin 5. Imidaclorprid 6. Karbofuran 7. Triazofos 8. Cymoxanil twice/week	- 38 days after planting 1. Karbofuran 2. Mankozeb, Mefendoksam 3. Betasiflutrin twice/week
8. Harvest	80% yellow plants	80% yellow plants	80% yellow plants	80% yellow plants