Cropping management on potato field, a strategy to suppress pest by increasing insect diversity and natural enemies

Lamria Sidauruk* and Patricius Sipayung

Department of Agrotechnology, Universitas Methodist Indonesia, Medan Indonesia
Faculty of Agriculture, Universitas Katolik Santo Thomas, Indonesia

Abstract. Stability of ecosystem and ecological resilience indicate by the species composition of arthropods on agro-ecosystem. Intensive agricultural action will cause agroecosystem damage by decrease of biodiversity and disruption of landscaping agricultural. This study aimed to determine the ability of cropping management increasing the diversity of insects and natural enemies of pest on potato field, this method can application as a component on integrated pest management strategy to suppress pest on potato field. Crop management is doing by intercropping, organic farming systems and setting the growing season of potato. The result showed that insect diversity index and natural enemies population on intercropping system is higher than monoculture system, while the pest populations is lower. Insect diversity index and natural enemies population in organic systems on farm is higher than conventional farming systems, in general the pest population was lower in conventional farming systems, but not significant with organic farming system. The intercropping potatoes+cabbage+mustard+celery, potatoes+cabbage, potato+mustard respectively which grown by organic farming systems provide the highest insect diversity on farm. Natural enemies population increase in order to increasing insect diversity and suppress population of pest. Management on growing season showed that population of Coccinellidae at May-August more higher than September-Desember. On the other hand, population of Braconid wasp at May-August more lower than September-Desember.

Keywords: cropping management, insect diversity.

1. Introduction

Management on cropping was commonly done through the arrangement of plant types and planting time over a period of years [1-3]. Manipulation of habitat of farmland vegetation can give direct suppressive effects on pests and promoting the population of natural enemies on field. The advances studies of this topics indicated that habitat management becoming an important subdiscipline for theory and technical on pest management. The main goal of pest management is to control pests by utilizing biotic factors and modification in agricultural environment. Improvement understanding about function of ecosystem and its relationships with biodiversity become a basis on development theoretical foundation on which to design habitat management strategies for pest suppression in agricultural systems. Design habitat including effect of landscaping for biological agents. Understanding for this mechanisms, habitat management is an important component of conservation biological agent for biological control [4].

The greatest threats to biodiversity was using agricultural constitutes such as pesticide and fertilizer [5]. Aplication synthetic insecticide are standard practice in conventional farming systems.
The farming choose synthetic insecticide because can using simplicity, more cheap and effective to control pest at the short time. On pest management strategy, sustainability and effectiveness of this strategy is being questioned [6]. Besides that, the side effects of synthetic insecticides are recognized clearly, such as negative impacts on human health by contamination on agricultural product, losses on biodiversity, air and water pollution, and increasing resistance in targeted pests [7]. Nowadays, the consumer have considered these side effects, leading to increased demand for pesticide free crop production [8]. Efforts needs to increase diversity in the agroecosystem by application mix cropping and minimize using pesticides to control the pests. Increasing biodiversity seems have positive correlate to reducing pest outbreaks on agroecosystem [9], explanation about this mechanism not always clearly, so need more studies to explained.

Intercropping or multiple cropping means practice of growing different crops in the same field at the same time. Many possibility of spatial combinations for intercropping, including mix cropping or relay cropping. It means, the different crops are planted in the same row or different, which involving planting different crops in alternate rows. The other model of multiple cropping is planting one or more crops on the same plot during different times of the year. Te benefits of multiple cropping or intercropping, such as increasing beneficial insects, reducing insect pest populations, and suppression of weed [10]. There had been demonstrated that alternative prey present on farm can be facilitate a suppression of pest by increasing population of potential predation and parasitism. Many species of predators and parasitoids use the plant resources of the semi-natural habitats located outside fields [11]. The strategy to control pest is Integrated Pest Management (IPM), mean combination of several methods controlling pest populations remains below the economic threshold and so that the use of pesticides can be minimized. Organic farming is a main strategy to control of pest populations by enhancing natural enemies populations [8].

Multiple cropping systems in organic farming provide a suitable environmental by offer a buffer capacity of yield by diverse growing demands and different periods of root, leave and seed development of the plant varieties [12]. Many opportunities offers by organic farming for enhancing biological control factor on field [13]. Many research reported that multiple cropping had many advantage in supressing pests incidence and disease damage in some areas by introducing certain plant species that are nonhosts for disease-causing agents and insects [14,15].

Learning about ecosystem, an arthropod can indicated the changing of ecosystem because its very sensitive to ecosystem disturbance [4,16]. Sometimes the reaction to environmental changes very fast, so can using as bioindicators. Arthropods function as bioindicators of habitat disturbance such as pollution and climate change [17,18]. Population of arthropods are abundant and easy to get sampling to observation, and so, they give more information per unit sample time [19]. Similarly, developing in arthropod biodiversity happen when monocultures are replaced by polycultures [20] and a variety of different habitats by dominated large crop fields [21].

Managing on cropping pattern in horticultural crops will be increase diversity and stability of ecosystems, farmers income increasingly, reducing on soil erosion and reducing pest investment and plant diseases [22]. Study about intercropping potato and celery showed that damaged on potato leaf reducing by Trips 44 percent and by aphids 55.6 percent, also shown that intercropping potato with maize and sunflower declining pest attacks by aphids M. Persicae [23]. Intercropping strategy with nonhost plants can be promotes leafhopper movement and ability to predation. Insect diversity studies is important in biological control systems. The study not only manipulated predator species richness, but also prey diversity, such that reciprocal effects of predator and prey diversity on herbivore suppression have not been explanated explicitly [24].

2. Material and Methods
The research has been carried out at Simalungun Distrik. North Sumatera two growing seasons namely May-August and September-December. The main plot are farming system consist of conventional, semi organic and organic farming. The sub plot are cropping system such as: monoculture potato (P1); potato+cabbage (P2); Potato+mustard (P3); potato+celery (P4);
potato+cabbage+mustard (P<sub>5</sub>); potato+cabbage+celery (P<sub>6</sub>); potato+mustard+celery (P<sub>7</sub>); potato+cabbage+mustard+celery (P<sub>8</sub>). The data of insect collect at plant sample or plot for every treatment. Collecting doing by sweeping net, light trap and fit fall trap. Identified of insect doing by using Kalshoven book identification of insect. Insect biodiversity index calculated based on the equation of Shannon. All data Analyzed using SAS statistical software and Tukey Range Test at 5% level of significance.

3. Results and Discussion

3.1. Insect diversity index

Analysis of variance showed that farming system and cropping system significantly affect the insect diversity index at 7 and 9 weeks after planting for growing season May-August and at 7 weeks after planting for growing season September-December (Table 1).

Table 1. Average insect diversity index at different cropping management on growing season May-August and September-December

| Farming System | Cropping system | May- August | Sep- Dec |
|----------------|-----------------|------------|---------|
|                |                 | 7 WAP* | 9 WAP | 7 WAP | 9 WAP |
| Sole Potato (Monoculture) | | | | | |
| Potato+Cabbage | 0.8ab | 1.2a | 0.9abc | 1.3 |
| Potato+Mustard | 0.8ab | 1.7abc | 0.9ab | 1.7 |
| Conventional farming (S<sub>1</sub>) | | | | |
| Potato+Cabbage+Mustard | 1.1abc | 1.8abcd | 1.2abcd | 1.7 |
| Potato+Cabbage+Celery | 1.0ab | 1.7abcd | 1.0abc | 1.5 |
| Potato+Mustard+Celery | 1.1ab | 1.7abc | 1.2abcd | 1.7 |
| Semi organic farming (S<sub>2</sub>) | | | | |
| Kentang-kubis (P<sub>4</sub>) | 0.9ab | 1.7abc | 1.2abcd | 1.7 |
| Kentang-sawi (P<sub>5</sub>) | 1.3abc | 2.6fgh | 1.4abcde | 2.7 |
| Organic farming (S<sub>3</sub>) | | | | |
| Kentang-seledri (P<sub>6</sub>) | 1.1abc | 2.0bcde | 1.2abcd | 2.0 |
| Kentang-sawi-seledri (P<sub>7</sub>) | 1.5bc | 2.3def | 1.9def | 2.8 |
| Kentang-kubis-sawi-seledri (P<sub>8</sub>) | 1.4bc | 2.5efg | 2.3fgh | 2.8 |
| average | 1.3 b | 2.2 b | 1.5 b | 2.4 b |

*WAP*: weeks after planting

Note: the same letter indicated not significantly differ based Tukey Range Test (F = 0.05)
Increasing biodiversity by intercropping system at organic farming had positive effects for species richness commonly observed among predator species may extend to pathogen communities as well, such that conserving pathogen biodiversity may carry additional benefits for biological control. In biological control communities, greater predator species richness often strengthens pest suppression [25,26]. The composition of the Lepidoptera changes with habitat size depending on the diversity of habitats in the landscape, particularly at the larger spatial scale [27,28]. Reduction in the incidence of pest attacks are very significant in the cropping pattern of intercropping maize with cotton compared to the monoculture cropping of corn and cotton [29]. Intercropping pattern in horticultural crops will be increase diversifitas and stability of agricultural ecosystems, increase farmers income, reduce soil erosion and reduce investment pests and plant diseases [22].

3.2. Natural enemies population
Result of this research indicated there were two kinds of natural enemies were predominantly found in the field, namely Braconid wasp and Coccinellidae. Analysis of variance showed that farming system and intercropping system significantly affect population density of the natural enemies at growing season May-August and September-December for observation at 7 and 9 weeks weeks after planting. The population of predator Coccinellidae at organic farming more higher than conventional farming but not significantly different with semi organic farming at two growing season. There is no difference population found at growing season May-August and September-December (Table 2). Cropping system and farming system significantly affect population of predator coccinellidae, but between the two growing seasons not significantly difference. The highest of population Coccinellidae found at intercropping potato+mustard which planting with organic farming, but not significant difference with intercropping potato+cabbage+mustard and potato+cabbage+mustard+celery (Figure 2).
Table 2. Population of predator coccinellidae at difference cropping management

| Cropping Management         | May-August | Sep-Dec |
|-----------------------------|------------|--------|
|                             | 7 WAP*     | 9 WAP  |
| Conventional farming        | 2.0 a      | 1.8 a  |
| Semi organic farming        | 4.2 b      | 4.3 b  |
| Organic farming             | 4.9 b      | 4.4 b  |
| Average                     | 3.6        | 3.5    |
| Sole Potato (Monoculture)   | 2.2 a      | 2.8 a  |
| Potato+Cabbage              | 2.4 a      | 3.0 a  |
| Potato+Mustard              | 4.8 b      | 4.6 ab |
| Potato+Celery               | 2.6 a      | 2.8 a  |
| Potato+Cabbage+Mustard      | 4.8 b      | 4.4 ab |
| Potato+Cabbage+Celery       | 3.0 ab     | 3.1 ab |
| Potato+Mustard+Celery       | 4.0 ab     | 4.4 ab |
| Potato+Cabbage+Mustard+Celery| 4.9 b      | 4.7 b  |
|                             | 3.6        | 3.7    |

*WAP : weeks after planting

Note : the same letter indicated not significantly differ based Tukey Range Test (F = 0.05)

Figure 2. Population of Coccinellidae at difference cropping management

Parasitoid Braconid wasp population more higher at organic farming than conventional farming at two growing season. The highest population found at intercropping potato cabbage+mustard+cabbage at growing season September-December (Figure 3).
Figure 3. Population of braconid wasp at observation 9 week after planting on growing season September-December

Population of natural enemies affected by cropping system showed that the higher population found at intercropping potato with cabbage, mustard and celery in two planting season. The number of braconid wasp significantly increased at intercropping potato+cabbage+mustard+celery, potato+cabbage and potato+mustard+celery respectively (Table 3).

Table 3. Population of braconid wasp at 9 and 11 weeks

| Plant age | cropping system                  | Planting Season | Ave |
|-----------|----------------------------------|-----------------|-----|
|           |                                  | May-Aug | Sep-Oct |     |
| 9 weeks   | Potato Monoculture               | 1.21     | 2.47    | 1.77 a |
|           | Potato+Cabbage                   | 1.49     | 3.72    | 2.62 ab |
|           | Potato+Mustard                   | 1.40     | 3.36    | 2.36 ab |
|           | Potato+Celery                    | 1.29     | 2.47    | 1.83 a  |
|           | Potato+Cabbage+Mustard           | 1.28     | 3.61    | 2.40 ab |
|           | Potato+Cabbage+Celery            | 1.23     | 2.14    | 1.72 a  |
|           | Potato+Mustard+Celery            | 1.32     | 3.72    | 2.44 ab |
|           | Potato+Cabbage+Mustard+Celery    | 1.59     | 4.53    | 3.15b   |
|           | Average                          | 1.35     | 3.25    | 2.29    |
| 11 weeks  | Potato Monoculture               | 1.22     | 1.61    | 1.35 a  |
|           | Potato+Cabbage                   | 1.47     | 2.17    | 1.88 c  |
|           | Potato+Mustard                   | 1.45     | 2.22    | 1.83 bc |
|           | Potato+Celery                    | 1.34     | 1.69    | 1.51 ab |
|           | Potato+Cabbage+Mustard           | 1.31     | 2.14    | 1.71 bc |
|           | Potato+Cabbage+Celery            | 1.33     | 1.86    | 1.61 abc|
|           | Potato+Mustard+Celery            | 1.39     | 1.97    | 1.59 abc|
|           | Potato+Cabbage+Mustard+Celery    | 1.58     | 2.81    | 2.38 d  |
|           | Average                          | 1.39     | 2.06    | 1.74    |

Note: the same letter indicated not significantly differ based Tukey Range Test (F = 0.05)

Decreasing population of natural enemies on conventional farming because of continuous application pesticide to control the pest. Pesticide also killed beneficial insect at the field. It can be seen from the natural enemy populations such as: braconid wasp and coccinellidae are higher in organic farming systems than conventional system at first planting season and second planting season. The population of natural enemies more higher at intercropping system than monoculture system. So.
Intercropping could be recommended as a strategy for plant protection to reducing pest population on the field.

There are various reasons as to why associating companion plants with crops in intercropping system might result in less aphid-caused damage therefore decrease the need for the application of pesticides. First, a intercrop plant may attract and draw pests away from the target crop. These plants, called trap plants, are more attractive to the pest, and this may divert them from their host plant. Then, by emitting volatile organic compounds (VOCs), certain intercrop plant can act either directly on aphids, by diverting their location from the target plant by repellence or masking host odors, or indirectly, by changing some traits of the host plant and making them unsuitable for aphids. Others can act on natural enemies by providing shelter and food, enhancing their abundance and strengthening their rates of predation or parasitism [30].

3.3. Pest Population
There are three main pest found at potato field such as Myzus persicae, Phthorimaea operculella and Liriomyza huidobrensis. The observation showed that farming system and cropping system significantly affect the population of pests at 9 weeks after planting on growing season May-August and September-December. The lowest population of pest found at intercropping potato+cabbage, potato+mustard and potato+cabbage+mustard (Figure 4).

![Figure 4. Population of pest at different cropping system](image)

Increasing insect diversity in agroecosystems will increase the natural enemy population of insect pests. Presence of alternative prey at intercropping system can facilitate biological pest suppression by increasing population of predator Coccinellidae and parasitoid Braconid wasp. Many species of parasitoids and predators use the plant resources as a habitat. The natural enemies can control population of pest on potato field.

4. Conclusion
Insect diversity index and population of natural enemies in organic farming systems more higher than conventional farming systems, but not significant with semi organic farming system. The intercropping potatoes+cabbage+mustard+celery, potatoes+cabbage, potato+mustard respectively which grown by organic farming systems provide the highest insect diversity index, the highest population of natural enemies and the lowest pest population. Population of predator Coccinellidae at growing season May-August more higher than growing season September-December. Population of parasitoid Braconid wasp at growing season May-August more lower than growing season
September-December. There are three main pest found at potato field such as *Myzus persicae*, *Phthorimaea operculella* and *Liriomyza huidobrensis*. The lowest population of pest found at intercropping potato+cabbage, potato+mustard and potato+cabbage+mustard.

References

[1] Glissman S R 2005 *Multiple Cropping System: A Basic for Developing an Alternative Agriculture* University of California St. Cruz p 69-83

[2] Nafziger E 2002 *Cropping System Department of Crop Sciences* 49-63

[3] Prabhu M, Kumar A R, Balasubramanian V and Jagdeesan R 2009 Cropping system in Tropical Vegetables *The Asian Journal of Horticulture* 4(1):245-250 2009

[4] Gurr G, Wratten S D, Landis D, Minsheng Y 2017 Habitas Management to Supress Pest Population *Ann Entomol* 62: 91 -109

[5] Fischer J, Brittain C and Klein A M 2013 Biodiversity-Friendly Farming *Encyclopedia of Biodiversity* Vol 1:418-429

[6] Krauss J, Gallenger I and Steffan-Dewenter I 2011 Decreased Functional Diversity and Biological Pest Control in Conventional Compared to Organic Crop Fields *PLoS One* 6:

[7] Pimentel D, Acquay H, Biltonen M, Ric P, Silva M, Nelson J, Lipner V, Giordano S, Horowitz A, and Amore M D 1992 Environmental and Economic Costs of Using Pesticide *BioScience* 10:750–760

[8] Bianchi F J J A, Ives A R and Chellhorn N A 2013 Conventional and Organic Farming for Biocontrol Services Across the Landscape *Ecological Applications* 23(7) 7 pp

[9] Letourneau D K and Sara G B 2008 Comparison of Organic and Conventional Farms *Frontiers in Ecology and the Environment* 6: 430–438

[10] Hugh A S and Oscar E L 2012 *Intercropping, Crop Diversity and Pest Management* UF/IFAS Extension 7 pp

[11] Elsa E É. 2012 *Agricultural Practices that Promote Crop Pest Suppression by Natural Predators* Review of the Literature Submitted to Agriculture and Agri-Food 40 pp

[12] Paulsen H M, Schochow M, Ulber B, Kuhne S and Rahmann G 2006 Mixed Cropping Systems for Biological Control of Weed and Pests in Organic Oilseed Crops *Aspects of Applied Biology* 79: 215-220

[13] Fouche C, M.Gaskell S T, Koike J, Mitchell and Smith R 2000 *IPM for Organic Crops Vegetable Research and Information Center* Vris.ucdavis.edu.p.1-5

[14] Jones V L 2007 *Multiple Cropping*. Agricultural Research Langston University Langston

[15] Jabbour R, Crowder D W, Aultman E A and Snyder W E 201. Entomopathogen Biodiversity Increases Host Mortality *Biological Control* 59: 277-28.

[16] Whish J P M, Herrmann N I, White N A, Moore A D and Kriticos D J 2014 Integrating Pest Population Models *Environmental Modelling & Software XXX*: 1-8

[17] Colbach N 2010 Modelling Cropping System Effects on Crop Pest Dynamics: How to Compromise Between Process Analysis and Decision Aid *Plant Science* 179: 1-13

[18] Chidawanyika P, Mudavanhu and Nyamukondiwa C 2012 Biologically Based Methods for Pest Management in Agriculture under Changing Climates *Insects 3*: 1171-1189

[19] Hill S B 1989 Cultural Methods of Pest Primarily Insect Control *EAP Publication* – 58 Macdonald College of McGill University Canada

[20] Andow D A 1991 Vegetational Diversity and Arthropod Population Response *Annu. Rev. Entomol.* 36 561-586

[21] Altieri M A 1999 The Ecological Role of Biodiversity in Agroecosystem *Agriculture Ecosystems and Environment* 74:19-31

[22] Tankou C M 2014 Effect Of Green Manure And Intercropping On Potato Production In The Western Highlands Of Cameroon *International Journal of Scientific & Technology Research* vol 3 (9): 204-208
[23] Sidauruk L, Bakti D, Kuswardani R A and Hanum C 2018 Effect of Cropping Systems and Farming Systems to the Diversity of Insects on Potato Field in Karo Highland Proceeding of 6th International Conference on Global Resource Conservation ICGRC 2018

[24] Straub C S, Simaek N P, Dohm R, Gapinski M R, Aikens E O and Nagy C 2014 Plant Diversity Increases Herbivora Movement and Vulnerability to Predation Basic and Applied Ecology 15: 50-58

[25] Leteourneau D K and Ariana van B 2005 Crop Protection in Organic Agriculture a Global Perspective Chapter 4 pp 93 -21

[26] Rahmann G 2011 Biodiversity and Organic Farming: What do we know? Agriculture and forestry research 3 (61): 189-208

[27] Fuller R J, Norton L R, Feber R E, Johnson R P, Chamberlain D E, Joys A C, Mathews F, Stuart R C, Townsend M C, Manley W J, Wolfe M S, McDonald D W and Irbank L G F 2005 Benefit of Organic Farming to Biodiversity Vary Among Taxa Biol Lett 1:431-434

[28] Botham M S, Fernandez-Ploquin E C, Brereton T, Harrower C A, Roy D B and Heard M S 2015 Lepidoptera Communities Across an Agricultural Gradient: How Important are Habitat Area and Habitat Diversity in Supporting High Diversity? Journal Insect Conservation Pub Online 19 February 2015 17 p

[29] Sharaby A, Abdel-Rahman H and Moawad S S 2015 Intercropping System for Protection the Potato Plant from Insect Infestation Ekologia Balkanica 7 (1): 87-92

[30] Ben-Issa R, Laurent G and Hélène G 2017 Companion Plants for a Ahid Pest Management. Insects 8 (4) 11

Acknowledgments
This research supported by Universitas Katolik Santo Thomas Indonesia and Universitas Methodist Indonesia Medan.