Population of Myzus persicae (Sulzer) and insect diversity on intercropping potatoes with other plants which planting at different time

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Abstract. Crop management has long been known influenced the development of pest populations on agroecosystem. Arrangement of crop by intercropping system on potato field expected to increase insect diversity and suppress populations of Green peach aphid (Myzus persicae Sulzer). Crop management consists of sole potato, potato with cabbage, potato with celery, Potato with onion, potato with mustard, potato with bean and potato with carrot. The intercrop plants were planting at different time that is one week after potato, two weeks after potato and three weeks after potato. Observation and identification of insect begin at three weeks until 11 weeks after potato planting with an interval two weeks. The results showed that the planting time of intercrop plant no significant effect on the population of M. persicae and insect diversity index. The interaction of planting time and kind of intercrop plant has significant effect on population M. persicae and insect diversity index. There are different population dynamics of green peach aphid in different crop management. Observation at 9th week after planting indicate that the lowest number of aphid found respectively in intercropping potatoes with celery, potato with mustard and cabbage. The interaction of planting time and kind of intercrop plant has significant effect on insect diversity index. Observation for insect diversity showed that the highest insect diversity index found at intercropping potato with mustard, potato with bean and potato with cabbage for all observation. In order to increasing the insect diversity, a few natural enemies of M. persicae found in the agro-ecosystem.

Keywords: M. persicae, crop management, potato

1. Introduction

District Karo highlands of North Sumatra is the third largest potato production center in Indonesia after Central Java and West Java. Green peach-potato aphid (M. persicae Sulzer), apart of order Hemiptera and family Aphididae is important pests on potato in North Sumatra. This aphid, is a polyphage species found among the most harmful aphid species associated with vegetables such as potato, cabbage, beet and cauliflower, cause significant losses for plants by direct damage through attacks on plant leaves and indirect damage by transmitting important non-persistent viruses. This pest commonly a serious pest of several crop worldwide and has a very complex life cycle. Has been reported that more than 300 host plants in over 66 plant families [1]. M. persicae also infests vegetables and ornamental plants grown in greenhouses, shows considerable genetic variation with...
The high adaptability of aphid allows to survive in different weather and host plant. These aphids also can be transported long distances by wind and storms [2].

*M. persicae* can attack potato plant from young plant until harvest, especially high population at young leaves. Damaged on young plant tissues causing water stress, wilting and reduced growth rate of the plant. Aphid infestation for a long time can reduction the yield of potato. Because this aphid also transmitting viruses, the yield loses caused by these viruses can reach until 90% depending on plant cultivar, time of infestation and environmental conditions [3]. There are different life cycle of *M. persicae* in order to the season. It can be holocyclic or anholocyclic [4]. Because of the adaptability and colonization capabilities of some ecological systems or plants, the study of aphids is an interesting thing which includes aspects (vivipar, ovipar and parthenogenesis, plant physiological aspects, and behavioral aspects). Aphids have a complex life cycle, and their classification depends on the host plant and its reproductive system. Most of the species have parthenogenesis and sexual reproduction. Parthenogenesis generally occurs due to climatic factors namely changes in temperature and day length [5].

Intercropping defined as planting two or more plants on the same land at the same time with good arrangement. This method is adopted sustainable agriculture concept which at least use nature as the model for designing agricultural systems. The major aim of sustainable agriculture is efficiency and there are no waste products in nature. This plant arrangement which promote diversity and stability on the farm by crop diversification, crop rotation, planting wind breaks, provision of more habitats for microorganisms, intercropping, integration of crop farming with livestock production and agrosilvipastoral [6]. Many studies showed that multiple cropping with different plant arrangement has been advantageous in reducing damage by insect pests and disease. In some areas through diversifying the cropping system by introducing plant species that are nonhosts for certain insects and diseases [7,8].

Intercropping patterns effectively reduce pests in agro-ecosystems. Reduction in the incidence of pest attacks are very significant in the cropping design of intercropping maize with cotton compared to the monoculture [9]. Intercropping design in horticultural crops will be increase diversivity and stability of agricultural ecosystems, increase farmers income, reduce soil erosion and reduce pests infestation and reduce damage of plant by diseases [6]. Research reported that intercropping potato and celery can decrease damage of leaf caused Trips by 44 percent and caesed *M. persicae* by 55.6 percent in the potato crop [10], other research reported that there are declining on potato attacks by aphids *M. persicae* on potato intercropping with maize and sunflower [11]. This is due to differences habitat in monoculture and polyculture/intercropping. At monoculture, resource concentration suggests habitats more susceptible to herbivory because sources of food larger and concentrated and easier for herbivores to locate and exploitation. Difference with polyculture, the more types of plants at same field, the more herbivores indeed. It will be invite natural enemies of that herbivores. The natural enemy hypothesis suggests that natural enemies will be more abundant in complex ecosystems due to increased alternate prey items and more congenial microhabitats. These hypotheses inspired to investigating the influence of increased plant diversity on insect pest suppression and insect diversity [12,3]. Designing in plant diversity as a strategy to control the pest may depend on several factors consist of companion plant, intercropping design, sowing time, and all forms of polyculture that have been shown to reduce pest insect numbers in crops. However, in a number of studies showed where diversity of plants within the crop was increased, pest numbers were not reduced. The effects may be variable depend on many factor [14,15].

Why plant diversity can reduces herbivore abundance and reduce plant damage? This question can be explained by two hypotheses. First, Resource concentration hypotheses. The resource concentration hypotheses states that insect herbivores are more likely to find and remain on their host plants in monocultures, where their host plants are concentrated, than in polycultures, where their host plants are dispersed among nonhost plant species [16,17]. Under the resource concentration hypothesis, plant diversity reduces herbivore by reducing the relative abundance of herbivores host plants. This, in turn, reduces herbivore encounter rate with, or residence time on, hostplants. Second, The enemies hypotheses states that natural enemies are less abundant and/or more effective in monocultures than in...
polycultures, because polycultures include plant species that provide enemies with alternative prey, shelter, or a favorable microclimate [17]. Under the enemies hypothesis, plant diversity reduces herbivore by providing resources to enemies that control herbivore populations [18,20]. Diversification schemes that promote both the resource concentration and enemies hypotheses will be more effective than schemes that promote only one of them. However, these mechanisms are not always compatible. Increasing plant diversity by polyculture or intercropping may reduce herbivore abundance by a resource concentration effect, but may simultaneously reduce the foraging efficiency of natural enemies [18-20].

The purpose of this study is to determine the kind of plants intercropping to be applied with potato plant at different planting time, so its can be increase the diversity of insects at agroecosystem in order to suppress pest infestations of Myzus persicae Sulzer. So, this study expected to provide information about the planting system of potato which effective to supress pest attack on potato field.

2. Materials and methods
The research carried out at BBI Kentang, Kutagadung, Berastagi. Intercrop plant planting at three planting time such as: planting at the same time with potato (T1); planting 1 week after potato (T2); planting 2 weeks after potato. Crop arrangement doing by sole potato (P1) and intercropping potato with cabbage (P2), potato with celery (P3), potato with onion (P4), potato with mustard (P5), potato with bean (P6) and potato with carrot (P7). Every combination replicate at three times. Each plot was 3 m x 5 m, row to row distance was 75 cm and plant to plant was 30 cm all agronomic actions are carried out according to recommendations. Insect observation recorded from the date of start initial aphid infestation at 3rd after planting until the 11th weeks after planting.

2.1. M. persicae Population
Aphids were collected from three tagged leaves on each plant, one each in the top, middle and lower regions of three randomly selected plants, avoiding the border rows, from each plot. Mean aphid population per leaf was calculated for every observation. The data was recorded on the same leaves on weekly basis.

2.2. Insect diversity
Patterns of species diversity and community structure of insects associated with potatoes intercropping plant collected at 3rd weeks after planting until 11th weeks after planting. Collecting doing by sweeping net, light trap and fit fall trap. All insect identified by using Kalshoven book identification of insect. Insect biodiversity index calculated based on the equation of Shannon-Wiener.

3. Results and Discussion
3.1. M. Persicae Population
Analysis of variance showed that the planting time of intercropping plant did not significantly affect the population of M. persicae. This is because the particular pest that attacks potato leaves generally begin to attack the potato crop during a month after planting. The population of M. persicae significantly affect by crop arrangement with intercropping. The different kind of intercropping plant significantly affect the population of aphid. There are different aphid density at different kind of intercrop plant. Population density of M. persicae significantly increased during 3rd weeks after planting until 9th weeks and then decrease at 11th weeks after planting. The first observation of population at three weeks after planting of potato and the highest density found at 9th weeks after planting. This is because plants are in the maximum growth phase. At 9th weeks found the lowest number of aphid population found respectively in intercropping potatoes with celery, potatoes with mustard, potatoes with cabbage (Table 1). This is presumably due to the presence of cabbage, mustard and celery in potato cultivation affecting the relationship between M. persicae and potato plants as the host. A qualitative studies of cropping models reported that influence patterns of interaction between different plants and herbivores, including neutral, antagonistic and mutualistic interactions [16]. It is important to know the interaction between mutualism plant and herbivores that can be used in pest management in agricultural ecosystems. Pest infestation in
an agroecosystem is strongly influenced by the temporal dynamics of the ecological system that can be used as a framework for biological control strategies in sustainable agricultural systems [8].

### Table 1. Population of *M. persicae* per leaf on different intercropping plant

| Planting system          | 3 weeks | 5 weeks | 7 weeks | 9 weeks | 11 weeks |
|--------------------------|---------|---------|---------|---------|---------|
| Potato                   | 0.75    | 3.17 b  | 7.03 c  | 8.14 c  | 5.86 a  |
| Potato with cabbage      | 0.83    | 1.72 ab | 3.50 a  | 4.31 a  | 3.28 ab |
| Potato with celery       | 0.89    | 1.72 ab | 3.69 a  | 3.81 a  | 2.92 a  |
| Potato with onion        | 0.86    | 2.36 ab | 5.08 b  | 4.64 a  | 4.67 bcd|
| Potato with mustard      | 0.58    | 1.44 a  | 3.44 a  | 4.11 a  | 3.58 abc|
| Potato with bean         | 1.06    | 1.92 ab | 6.08 bc | 6.00 b  | 4.78 bcd|
| Potato with carrot       | 0.92    | 2.36 ab | 6.83 c  | 7.00 b  | 4.92 cd |

Note: Analyzing the results with ANOVA and Tukey test at P 5%.

Another factor that might cause the low population of *M. persicae* in intercropping of potatoes with cabbage and potatoes with celery are the presence of volatile compounds produced by these plants that affect the pest population in potato plants. The results of the study showed that there were significant differences in the population of *M. persicae* in different intercropping plant due to the presence of volatile compounds released by different plant. Celery produced volatile compounds which can acting as a repellent, so avoid *M. persicae* attack the plants.

Many research reported that intercropping of potatoes and celery can reduce Trips pest attack about 44 percent and *Myzus persicae* by 55.6 percent on potato crops, and the intercropping system of potato and celery is financially most profitable, with marginal returns of 81.45 percent [10]. Compare to sole potato, intercropping potato with onion reduced *M. Persicae* attack about 62.69 percent [15] and intercropping with brassica reduced population of aphid on potato [21].

At observation 9th weeks after planting showed the different population of *M. persicae* still at different intercrop plant which planting at different time (Figure 1).

![Figure 1. *M. Persicae* population at 9 weeks at different intercrop plant which planting at different time](image)

### 3.2. Insect diversity

Analysis of variance showed that the planting time of intercropping plant did not significantly affect the insect diversity index. On the other hand, interaction of planting time and kind of intercropping were
significantly affect insect biodiversity index. There are variation on insect diversity index in different kind of intercropping plant for every observation. Observation showed that insect diversity index increase from recording at 3rd weeks after planting until 9th weeks after planting, and the decrease at observation 11th weeks after planting. At 9th weeks observation showed insect diversity index at different intercropping plant and planting time (Figure 2).

![Figure 2](image)

**Figure 2.** Insect diversity index on different intercropping plant and planting time at 9 weeks after planting

Insect diversity index significantly increased during 3rd weeks after planting until 9th weeks and then decrease at 11th weeks after planting on potato with intercropping plant compare to sole plant. Interaction of the kind of intercropping plants and planting time significantly increased insect diversity index. The higher insect diversity index at 9th week recorded respectively at intercropping potatoes with mustard, potatoes with bean, potatoes with cabbage (Table 2).

### Table 2. Insect diversity index on different intercropping plant

| Planting time         | Insect Diversity Index |
|-----------------------|------------------------|
|                       | 3 weeks    | 5 weeks    | 7 weeks    | 9 weeks    | 11 weeks   |
| Planting at the same time with potato(T1) | 0.47   | 0.65b   | 1.40     | 1.54     | 1.42   |
| 1 week after potato (T2) | 0.41   | 0.60ab  | 1.38     | 1.58     | 1.43   |
| 2 weeks after potato (T3) | 0.37   | 0.53a   | 1.34     | 1.68     | 1.34   |
| Planting system       |            |           |          |          |          |
| Sole potato (P1)      | 0.31ab   | 0.61abc  | 1.28bc   | 1.59b    | 1.40bc  |
| Potato with cabbagge(P2) | 0.51b       | 0.69c    | 1.55d    | 1.71b    | 1.55cd  |
| Potato with celery(P3) | 0.28a   | 0.44a    | 1.05a    | 1.18a    | 1.02a   |
| Potato with onion(P4) | 0.47ab   | 0.53ab   | 1.12ab   | 1.30a    | 1.13a   |
| Potato with mustard(P5) | 0.48ab    | 0.68bc   | 1.74e    | 1.98c    | 1.73e   |
| Potato with bean(P6)  | 0.48ab   | 0.63bc   | 1.56d    | 1.80bc   | 1.58d   |
| Potato with carrot (P7) | 0.37ab  | 0.57abc  | 1.33c    | 1.65b    | 1.38b   |

Note: Analyzing the results with ANOVA and Tukey test at P 5%.

The results showed that there was an increase in the type of arthropods found on the land with intercropping design when compared with the design of monoculture. Arthropod types that are found in
many plantations are insects and spider. Arthropod communities are found on terrestrial land in plantations and weeds above the soil surface. There are an increase in the value of the diversity index in all treatments with intercropping designs [22]. The higher diversity index was obtained in the design of intercropping potato with mustard and potato with bean. This shows that in experimental plots with increasingly high plant diversity, it also significantly increased arthropod diversity in the experimental plot. Insect diversity index 1.98 is categorized as moderate diversity, in order to Krebs. When compared with monoculture planting systems, the intercropping system actually increases the insect diversity index in potato crops.

The results of research on other agroecosystems ensure that increasing plant diversity can increase the abundance and diversity of entomofaga predators [23]. Insect diversity in a land can increase herbivorous mobility and predation activity in cropping. Insect diversity in a habitat is strongly influenced by the landscape and diversity of the habitat. There are few natural enemies of M. persicae found in the agro-ecosystem. There are Episyrphus balteatus, Chrysoperla carnea, Aphidius matricarieae and Coccinella septempunctata. In order to this research, there are decrease of population of M. persicae with respect to improvement insect diversity.

4. Conclusions
Intercrop plant significantly reduced the population of M. persicae on potato intercropping compare to monoculture of potato. At 9th weeks after planting found the lowest population of M. persicae respectively in intercropping potatoes with celery, potatoes with mustard and potatoes with cabbage. The kind of intercropping plants significantly increased insect diversity index on potato intercropping. The higher insect diversity index obtained at intercropping potato with mustard and potato with bean.

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