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# THE INFLUENCE OF CULTURAL PRACTICE ON POPULATION OF PEA LEAFMINER (*Liriomyza huidobrensis*) AND ITS PARASITOIDS IN POTATO

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## ABSTRACT

Pea leafminer (*Liriomyza huidobrensis*) is the major pest of potato crop in Indonesia. The use of insecticides to control the pest is ineffective and harmful to the natural enemies. The study aimed to find out a promising cultural practice for leafminer management on potato crop. The study was conducted at a farmer's field in Bali in 2004. Potato plants (Granola variety) were grown in a raised-bed plot of 10 m x 1 m. The treatments evaluated were standard cultural practice (C), C plus reflective plastic mulch (RPM) (CM), farmer's practice (F), vermicompost (V), and V plus RPM (VM). All treatments were arranged in RCBD with five replications. From each plot, 10 plant samples were randomly taken to observe the presence of larvae, mines, and adults. Larvae and adults of leafminer and mines were separately counted from the top, middle, and bottom parts of the plant samples. Parasitoids were collected from the infested leaves of the plant samples. Emerged parasitoids were counted and put into vials with 70% ethyl alcohol and then identified. The results showed that the population of adults, larvae of *L. huidobrensis*, and mines were less in C, CM, V, and VM treatments compared to farmer's practice (F). However, RPM (CM and VM) treatments significantly reduced population of leafminer and mines. The highest population of adults, larvae, and mines on RPM treatment were less than 1.5, 8.5, and 10 per plant, respectively compared to other treatments which were greater than 3.2 for adults, 12.4 for larvae, and 12.7 for mines. Parasitoid population and parasitism level were more in vermicompost treatments (V and VM) compared to other treatments (C, CM, and F). The results showed that application of pesticides was ineffective against leafminer and reduced parasitoid population; in the other hand RPM was effective to control leafminer although the effect on parasitoids was not clear. Parasitoid species that were found associated with potato crop were *Hemiptarsenus varicornis*, *Neochrysocharis* sp., and *Opius* sp. Combination of RPM with standard practice and vermicompost are prospective for leafminer management in potato crop, however, VM is friendlier to environment regarding sustainable agriculture.

[***Keywords***: *Solanum tuberosum*, cultivation, *Liriomyza huidobrensis*, parasitoids]

## INTRODUCTION

Potatoes have currently been threatened by the pea leafminer (*Liriomyza huidobrensis* Blanchard), an exotic and highly polyphagous and chemically resistant pest that attacks a wide range of vegetables, ornamental plants, and weeds (Parrella and Bethke 1984). The first documented infestation in Indonesia occurred in Java in 1994 (Rauf 1995; Shepard *et al*. 1996) and infested almost all potato crops in Java, Sumatra, Sulawesi, and Bali (Shepard *et al*. 1998; Darmiati *et al*. 2002).

Potato is very vulnerable to *L. huidobrensis*. The use of insecticides to control the pest was ineffective and harmful to the population of natural enemies (Nugaliyada 2000; Civelek and Yoldas 2003). *L. huidobrensis* significantly reduced potato yield in Central Java, West Sumatra, and North Sumatra by 30-70% (Rauf *et al*. 2000), and in West Java by 100% during the 1996 wet season (Shepard *et al*. 1998). Over 35 conventional insecticides were used to control *Liriomyza* spp. on potato crops in Indonesia (Rauf *et al*. 2000) but only abamectin and cyromazine which were effective. However, both insecticides were expensive, therefore, only few farmers could use the insecticides (Mujica *et al*. 2000; Rauf *et al*. 2000; Prijono *et al*. 2004).

Since only few insecticides were effective against pea leafminer, other control measures such as biological and cultural control should be developed to control *L. huidobrensis* (Fliert *et al*. 1998). There were 11 parasitoids of *Liriomyza* spp. found in Indonesia but the most common was *Hemiptarsenus varicornis*, although its occurrence in potato plants was relatively low (Rauf *et al*. 2000).

Other approach to manage the leafminer is by improving plant health using vermicompost, an organic fertilizer that has been introduced over the last few years, especially in organic farming. Vermicompost is finely organic materials and has high porosity, well aeration and drainage, high water holding capacity, and contains readily available nutrients for plants, therefore it will improve plant health and tolerance to pests and diseases (Subler *et al*. 1998; Atiyeh *et al*. 2000; Atiyeh *et al*. 2001).

In recent years, reflective plastic mulch (RPM) has been used in cultural practices of different crops, and reported to be effective against pests. Aquino and Mabesa (2002) found that application of RPM improved honeydew melon yield and lowered incidence of pests. RPM was also effective in repelling aphids and other pests in some vegetable crops (Smith *et al*. 2000; Summers *et al*. 2004; van Toor *et al*. 2004). The present study was conducted to find out cultural practices as a part of integrated pest management for controlling leafminer in potato crops.

## MATERIALS AND METHODS

The experiment was conducted at a farmer's field in the highland vegetable production center at Pancasari, Buleleng, Bali from August to November 2004. Potato plants (Granola variety) were grown in a raised-bed plot of 10 m x 1 m. The treatments evaluated were a standard cultural practice (C), C plus RPM (CM), farmer's practice (F), vermicompost (V), and vermicompost plus RPM (VM) (Table 1). The plots were arranged in a randomized complete block design (RCBD) with five replications.

From each plot, 10 plant samples were randomly taken to observe the presence of mines, larvae, and adults. Leafminer population was counted from the plant samples every week from the third week after planting (WAP) until one week before harvest. The presence of parasitoids was determined weekly by collecting 10 infested leaves from each plant sample. The infested leaves from the field were brought to the laboratory and placed in plastic containers (25 cm diameter and 25 cm high) and the lids were mounted with upside down funnels. A small plastic cup was assembled on the funnel stems to trap the emerging parasitoids and flies. All caught parasitoids and flies were counted and placed into vials with 70% ethyl alcohol for further identification. The identification was conducted in the Insect Systematic Laboratory, Department of Entomology, University of the Philippines Los Baños.

Data were analyzed using a statistical program, i.e. IRRISTAT for Windows 5 for analysis of variance (ANOVA). Mean comparison was done using least significant difference (LSD) at 0.05 levels.

## RESULTS AND DISCUSSION

### Population of *L. huidobrensis*

In the first two observations (3 and 4 WAP), population of the leafminer adults was quite low (0.03-0.18 individual per plant), hence the influence of the treatments was not apparent. The adult population increased after 4 WAP and significantly different among of the treatments ($P < 0.05$) after 7 WAP. Adult population was lower in RPM treatments (CM and VM) than other treatments (C, F, and V) (Fig. 1). The peak population of adults was observed at 9 WAP in F (3.21 individual per plant) and V (2.99), while at 10 WAP in C (3.26), CM (1.45), and VM (1.39). At the last observation (12 WAP), as there were no more fresh young leaves, adult population declined. These results agree with the report of Supartha *et al.* (2002) that adults start infesting potato plants at seedling stage and reach the peak at 8-11 WAP.

The results proved that RPM influenced the population of adults as sunlight reflected by RPM possibly

**Table1. Description of cultural practices on potato studied in the experiment, Buleleng, Bali, August-November 2004.**

| Application | Treatments[1] | | | | |
|---|---|---|---|---|---|
| | C | CM | F | V | VM |
| Vermicompost (t $ha^{-1}$) | 0 | 0 | 0 | 10 | 10 |
| Chicken manures (t $ha^{-1}$) | 30 | 30 | 35 | 0 | 0 |
| Urea (kg $ha^{-1}$) | 200 | 200 | 400 | 0 | 0 |
| Za (kg $ha^{-1}$) | 400 | 400 | 400 | 0 | 0 |
| TSP (kg $ha^{-1}$) | 250 | 250 | 400 | 0 | 0 |
| KCl (kg $ha^{-1}$) | 300 | 300 | 400 | 0 | 0 |
| Fungicide (chlorotalonil)[2] | No | No | Intensive | No | No |
| Insecticide (prophenophos)[3] | Selective | Selective | Intensive | No | No |
| Reflective plastic mulch | No | Yes | No | No | Yes |

[1]C = standard cultural practices; CM = C + reflective plastic mulch (RPM); F = farmer practices; V = vermicompost; VM = vermicompost + RPM.

[2]Intensive means, pesticides were applied intensively every 4 days.

[3]Selective means, insecticide was applied when necessary (every 14 days during experiment).

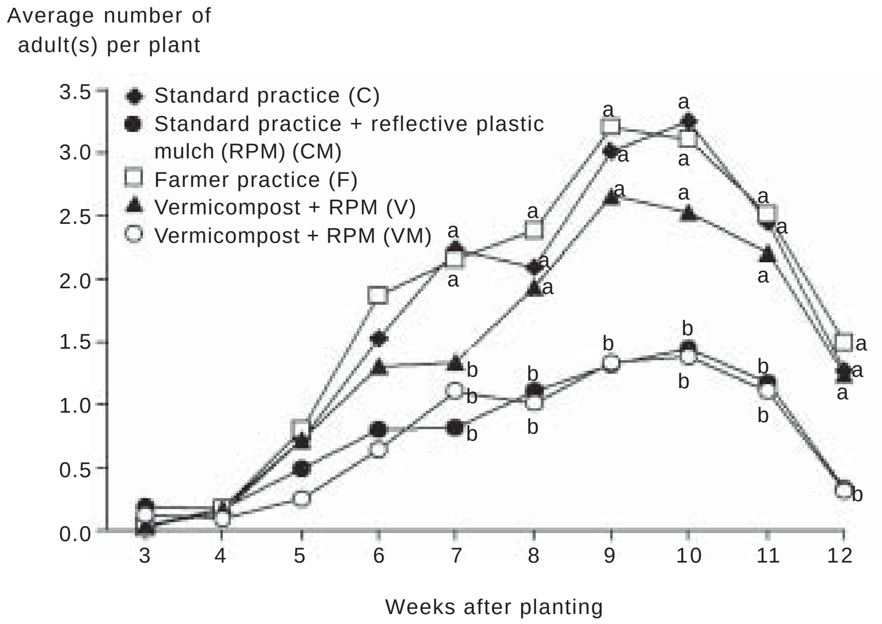


**Fig. 1.** Relative population of *Liriomyza huidobrensis* adults on potato crops with different cultural practices during the cropping season, Buleleng, Bali, August-November 2004. Common letters next to each point are not significantly different at 5% LSD.

disrupted the adults to perch on the plant. RPM has been reported to affect the movement and dispersal of adults of *Liriomyza* on tomato and squash plants (Wolfenbarger and Moore 1968). Further, RPM successfully suppressed population of several pests on crops, such as *Myzus persicae* and *Liriomyza* sp. on tomatoes (Wolfenbarger and Moore 1968), *Empoasca kraemeri* on dry bean (Cardona *et al.* 1981), *Aphis gossypii* and *B. argentifolii* on zucchini (Frank and Liburd 2005), *Lygus lineolaris* on strawberry (Rhainds *et al*. 2001), and *Thrips tabaci* on onion (van Toor *et al*. 2004).

The population of adults appeared to be related to the quality of leaves as adults prefer feeding and ovipositioning on young and soft leaves, possibly attributed to the physical and biochemical characteristics of the leaves. RPM indirectly improved plant resistance through better quality of leaves for feeding and ovipositioning (Cisneros and Mujica 1998; Wei *et al*. 2000; Martin *et al*. 2005). Direct beneficial effects of RPM on plant growth and development were reported with improved soil moisture, water and fertilizer efficiency, and increased quantity of product per unit of energy that stimulated plant growth and development (Karlen and Robbins 1983; Aquino and Mabesa 2002; Summers e*t al.* 2004). In addition photosynthetic rate resulting in great reflection of active radiation on the underside of the leaf could promote plant growth (Summers *et al.* 2004).

The number of larvae at 4 WAP and thereafter were lower in CM and VM (Fig. 2). Mines, as a result of larval activities, have a similar pattern to larval population (Fig. 3). The peak of larval population and number of mines was reached at 7 WAP and remained plateau until plant senescence. The pattern of larval population appeared similar to the adults. Fewer numbers of mines were observed in VM (7.14) and CM (7.79) than other treatments, C (11.89), F (12.34), and V (10.99) especially at 10 WAP and thereafter. The number of larvae and mines increased at later stages except with appear steady. This could possibly be attributed to the adult population, plant stage, and physical and biochemical properties of the leaves. Supartha (1998) found that the peak of adult oviposition was reached at 5 WAP and the population of larvae and mines rapidly increased thereafter. The low number of larvae and mines in CM and VM is probably a repelling effect of RPM to adults from ovipositioning on the plant, therefore larvae are not directly affected by RPM as they live within the plant (Parrella 1987).

Succulence and tissue structures of potato plant may influence larval feeding activities and developments (Martin *et al.* 2005). Thickness of the leaf and epidermis wall, densities of palisade and spongy tissues are important in mining and larval development, but thickness of the epidermis wall is not closely related to the percentage of leaf damage, since it is caused by larval feeding activities. Larvae of *L. huidobrensis*

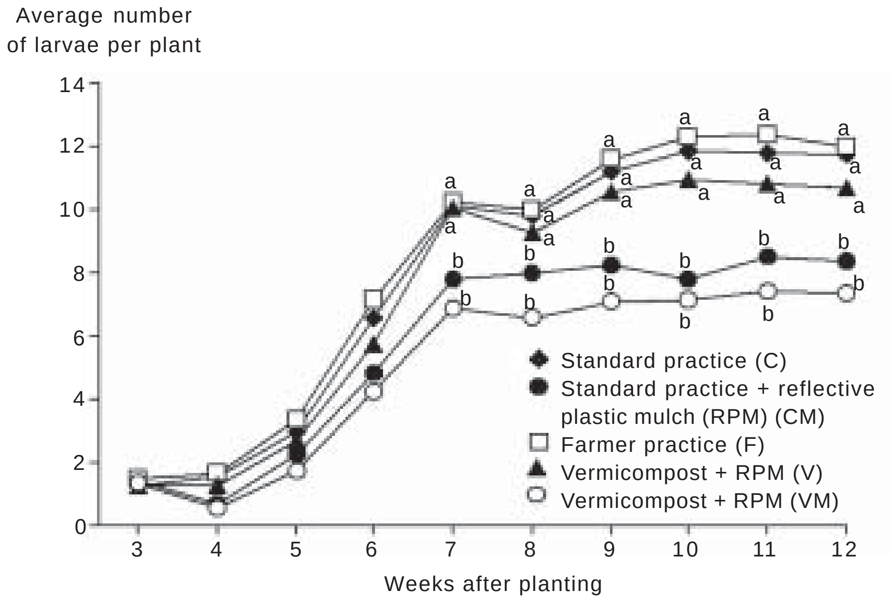


**Fig. 2.** Relative population of *Liriomyza huidobrensis* larvae on potato crops with different cultural practices during the cropping season, Buleleng, Bali, August-November 2004. Common letters next to each point are not significantly different at 5% LSD.

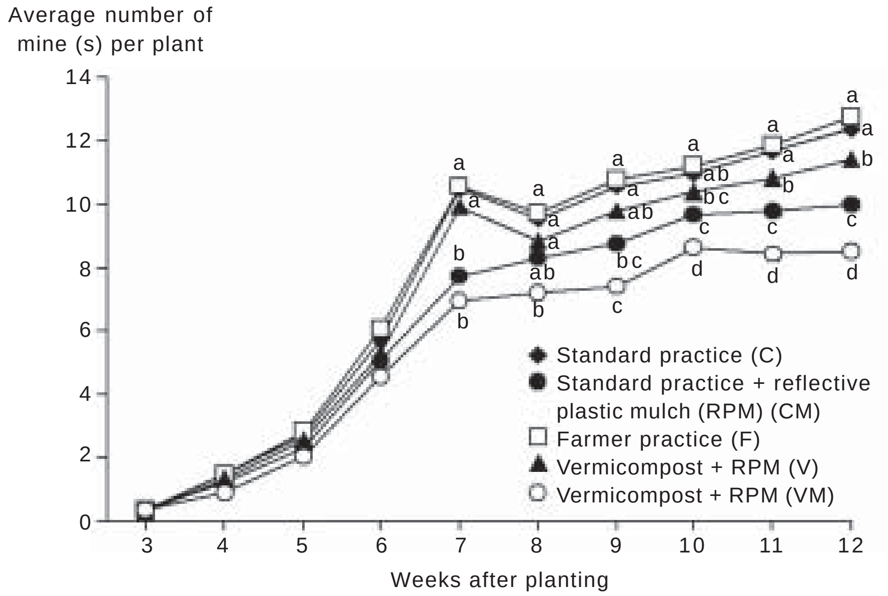


**Fig. 3.** Number of mines on potato crops with different cultural practices during the cropping season, Buleleng, Bali, August-November 2004. Common letters next to each point are not significantly different at 5% LSD.

feed on spongy tissues, therefore the density of spongy tissues is the most important factor influencing larval feeding activities (Wei *et al.* 2000).

Another factor that may affect egg and larval development is hypersensitivity reaction, which is a specific character of potato plants to damaged tissues. When an egg is laid in a growing leaf, the cells surrounding the egg start hypertropic growth that push the egg to the leaf surface (extrusion). The extruded eggs will be exposed to sunlight which results in dehydration or exposure to natural enemies. Egg extrusion is higher in vigorously growing plants, which are well fertilized and irrigated. The hypersensitivity reaction of leaf also affects the larvae, which results in the neonate larvae failing to burrow into the leaf tissues (Cisneros and Mujica 1998). RPM possibly may affect plant growth, which results in high egg extrusion. This phenomenon cannot be easily observed in the field; therefore data for egg extrusion were not able to collect during the experiment.

## Parasitoids of *L. huidobrensis*

Since parasitoids are host dependent, hence the parasitoids of *L. huidobrensis* were first observed at 4 WAP and more abundant in treatments without synthetic chemical inputs, V and VM. The peak of parasitoid population was reached at 12 WAP in V (8.19 parasitoids per plant) and VM (8.83). The number of parasitoids progressively increased in V and VM, whereas in other treatments it tended to be plateau (Fig. 4).

The levels of parasitism rapidly increased until 7 WAP and then levelled off. It was consistent with parasitoid abundance; the level of parasitism was always greater in V and VM during the cropping season. Starting at 7 WAP until the end of observation, the level of parasitism in VM was over 40%, whereas in V was slightly lower than VM but much greater than C, F, and CM (Fig. 5).

The parasitoid species of *L. huidobrensis* found during the growing season were *Hemiptarsenus varicornis* and *Neochrysocharis* sp. (Eulophidae) and *Opius* sp. (Braconidae). Shepard *et al.* (1996) reported that two species of parasitoids, *H. varicornis* and *Opius* sp. were observed to parasitize the larvae of *L. huidobrensis*.

Rauf *et al*. (2000) reported that *H. varicornis* was the most common and the most abundant parasitoid of *L. huidobrensis* in Indonesia followed by *Opius* sp. and *Neochrysocharis* sp. According to Supartha *et al*. (2002), *H. varicornis* is a common species and always associates with potato crops. *Opius* sp. is also abundant in Bali, especially on potato, tomato, celery, and wild crops in highland fields (Supartha, unpubl.) that might potentially control *Liriomyza* spp. Budiyasa (2003) reported that *Opius* sp. has a short life cycle and high fecundity, hence, ideal attributes of good parasitoid. The species of *Neochrysocharis* reported from Indonesia was *N. formosa* (Rauf *et al*. 2000). Current study reported a new species of *Neochrysocharis* that was identified as *N. beasleyi* from Indonesia (Bali) and Vietnam (Fisher and Salle 2005).

The effects of vermicompost and RPM on parasitoids were unclear. The abundance of parasitoids in vermicompost and RPM treated crops is probably due to the absence or less of pesticide application rather than the effect of the sunlight reflection. Frank and Liburd (2005) also reported that the populations of natural enemies of white fly and aphid on zucchini were not influenced by RPM.

Several studies documented the detrimental effects of chemical insecticides to parasitoids of leafminers on vegetable and ornamental crops (Poe *et al.* 1978; Schuster *et al*. 1979; Civelek and Yoldas 2003; Ferguson 2004; Prijono *et al*. 2004). In Indonesia, three chemicals were reported harmful to parasitoids and predators of *L. huidobrensis*, i.e. abamectin, dimehypo,

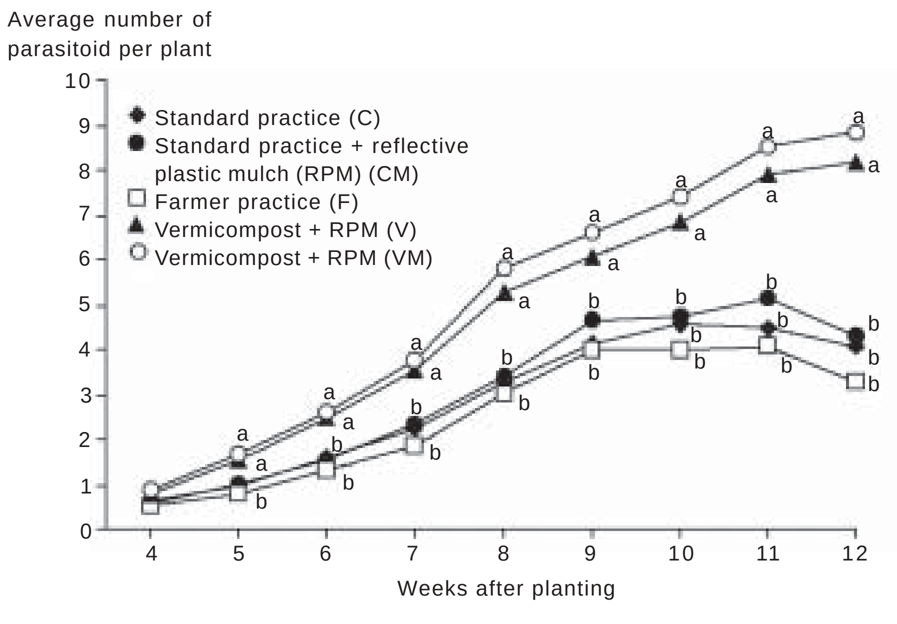


**Fig. 4.** Population of parasitoids of *Liriomyza huidobrensis* on potato crops with different cultural practices during the cropping season, Buleleng, Bali, August-November 2004. Common letters next to each point are not significantly different at 5% LSD.

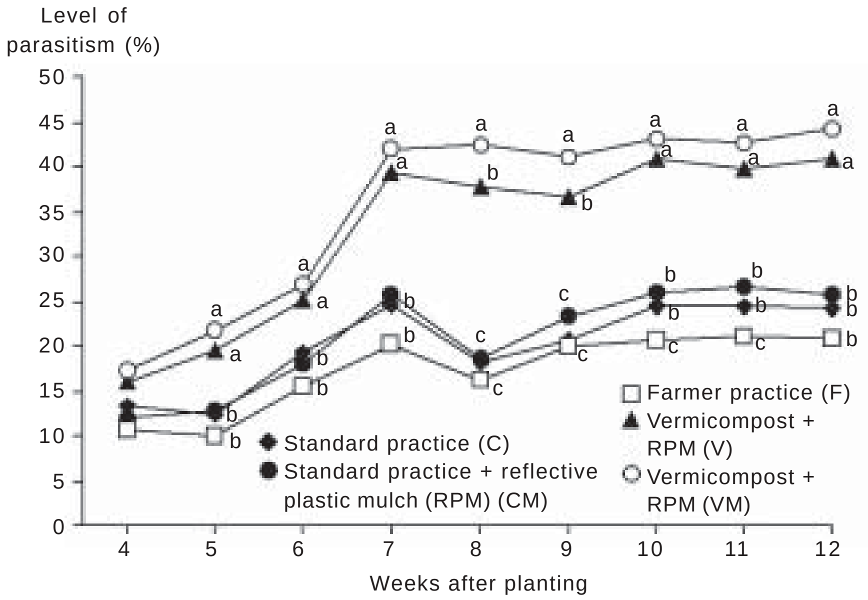


**Fig. 5.** Parasitism level of *Liriomyza huidobrensis* on potato crops with different cultural practices during the cropping season, Buleleng, Bali, August-November 2004. Common letters next to each point are not significantly different at 5% LSD.

and mancozeb (Prijono *et al.* 2004). In addition, Hidrayani *et al.* (2005) reported that the most common chemicals used by Indonesian farmers on vegetables (prophenophos and carbosulfan) were ineffective in controlling leafminers on potato crops and also harmful to natural enemies.

The level of parasitism was greater in non-chemical treated (V and VM) compared to treated with chemical (C, F, and CM) (Fig. 5). The level of parasitism was greatest in VM followed by V, CM, C, and F. The effects of RPM on parasitism level were probably on better crop performances, which directly influenced larval development of *L. huidobrensis*. Parasitoids of *L. huidobrensis* are affected by diet change in larval size. There is high correlation between parasitoids and larval size; the bigger the hosts, more female parasitoids were produced. *Opius* sp. was reported to prefer larger instars (third instars) of *L. huidobrensis* larvae and resulted in 77.21% female progenies (Budiyasa 2003). The preference to larger sized host is probably related to the adequacy of food supply for the parasitoid.

The abundance of the parasitoids of *L. huidobrensis* exhibited a host density-dependent pattern. The current study found that the abundance pattern of parasitoids is synchronous to the larval pattern. The density-dependent pattern of larvae and parasitoids was similarly reported with lettuce (Burgio *et al.* 2005). Murphy and LaSalle (1999) reported that the population dynamics of parasitoids follows the population dynamics of the leafminer, but when insecticides are used excessively, the population of parasitoids is usually disrupted.

## CONCLUSION

Reflective plastic mulch (RPM), in combination with standard practice (CM) or vermicompost (VM), reduced population of larvae and adults of pea leafminer (*L. huidobrensis*) and number of mines in potato crop, but its effect on parasitoids is not clear. However, both cultural practices (CM and VM) were prospective for leafminer management in potato crop. Between the two cultural practices, VM was more appropriate regarding to sustainable agriculture, but it will be applicable only for particular farmers who can easily find vermicompost. Several aspects, such as direct impact of vermicompost and RPM to plant health, soil quality, and microclimate under plant canopy, are needed for further study to complete some important information regarding potato crop management.

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