Insects Pollination of Zucchini Farming in Indonesia and their Economic Importance

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ABSTRACT
Insect pollination have an important role for the production of food crops, vegetables and fruits. Various studies have shown that pollination contributes very significantly to agricultural production, such as fruits, vegetables, fiber crops and nuts. Zucchini is one vegetable that depend on these ecosystem services. The purpose of this study was to analyze the economic contribution of insect pollinators on yield zucchini production at the farm level. To calculate the economic value of insect pollinators used bio economy model. The results showed that the dependence on bee pollinators zucchini plants is very high, bee pollinators not only affect the quantity of production but also can affect the quality of zucchini such as the size and weight of the fruit.

Key words: Vegetable, insect pollinators, zucchini farming, economic contribution, bioeconomy

INTRODUCTION
Pollination is an essential ecosystem services to agriculture provided by the natural habitat in the agricultural sector. There are around 150,000 pollinators mostly consist of flies, butterflies, moths, bees, wasps and beetles (Hein, 2009). Other than insect, birds, bats and some non-flying mammals also act as pollinator. Many crops especially vegetable require and benefit from insect pollination which improve the quality and yield (Morse and Calderone, 2000). Ricketts (2004) and Klein et al. (2007) reported that honey bees estimated to provide approximately 80% of all insect pollination. Further, reported by Kremen et al. (2002), benefit of pollinators is dependent on the crop species, geographical and habitat conditions and the use of insecticides.

Bees, like Apis florea and Apis mellifera is considered as the most efficient pollinator of many crop (Kevan and Phillips, 2001; Izadi et al., 2006; Greenleaf and Kremen, 2006; Khaghaninia et al., 2013; Munyuli, 2014).

Zucchini is one imported vegetable widely cultivated in Indonesia. Based on the study by Klein et al. (2007), level of zucchini dependency on insect pollinators is 95%. Thus, low pollinator population could lead to significant loss of production.

However, there is limited information available about pollinators of bees on Indonesia farming system. Furthermore, there has been no assessment of economic importance of insect pollination to farm. The objective of this study was to determine economic value of insect pollinators in zucchini farming based on portion of quality of zucchini produced.

MATERIALS AND METHODS
Study site: The study was conducted in small zucchini farms located at (1,312 and 2,084 m above sea level) Lembang, West Bandung District, West Java-Indonesia. Daily temperature ranged between 17 and 24°C with average annual rainfall about 1163 mm per year. The condition of zucchini farm showed in Fig. 1a-b.

Bee abundance was assessed by pan trapping and sweep netting as described by Morandin and Winston (2005). Bees were collected from traps and stored in 70% ethanol prior identification.
Fig. 1(a-b): Zucchini vegetable in the Farming Lembang, West Java-Indonesia

Fig. 2(a-b): Treatment of method insect pollination of zucchini farming, (a) Flowers with insect pollination and (b) Flowers with wind pollination

A total of 40 zucchini plants were randomly selected for pollination study. There were two types of treatment, wind pollination and insect pollination (open pollination), each 20 plants. From each flowers, two-three flowers which not bloomed, selected. Selected flowers for wind pollination (closed pollination) were covered by bag made of mesh (diameter 1 mm). Glue applied to the branch to prevent entry of ants to flower. Bagged was not removed until fruit produced. On the other hand, flowers for insect pollination were not covered with mesh bag (Fig. 2).

The frequency of bee pollinator’s visit to zucchini flowers were observed for 60 min during 3 days. Observation was carried out on different plants every day. Total number of visits at each plant zucchini was compiled from visitation data of three days (Klein et al., 2003). The quality of fruit production was determined by size and weight of the zucchini fruit produced of each treatment.

**Data analysis:** Data collected from this study was used to determine economic value and efficiency of bee pollination on zucchini.

**Efficiency:** The efficiency of pollination calculated using the formula:

\[
\text{Pollination efficiency} = \frac{\text{Total flowers bearing fruit}}{\text{Total flowers studied}}
\]

**Economic importance value:** This value was calculated based on Gallai et al. (2009) by:

\[
\text{EVIP} = D \times Q \times (P - C)
\]

where, EVIP is the economic value of insect pollinators, D is ratio of dependence on insect pollinators, Q is production (kg ha\(^{-1}\)), P is the price per unit and C is the cost of production per unit.

**Statistical analysis:** Data were analyzed using statistical test Independent samples t-Test.

**RESULTS AND DISCUSSION**

During this study, three species of Apidae was visited Zucchini flowers. The most abundant pollinator was eastern honey bee (Apis cerana) accounted 50% of total numbers of visitors (Fig. 3). This result agreed with some studies about the
Fig. 3(a-b): Zucchini fruit quality for both treatments, (a) Caged plant pollination and (b) Open plant pollination

Table 1: Visitation rate of bee pollinators during 3 days

<table>
<thead>
<tr>
<th>Visitation time (pm)</th>
<th>Apis cerana</th>
<th>Xylocopa sp.</th>
<th>Trigona sp.</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>08.00-09.00</td>
<td>34</td>
<td>3</td>
<td>14</td>
<td>51</td>
</tr>
<tr>
<td>09.00-10.00</td>
<td>60</td>
<td>4</td>
<td>20</td>
<td>84</td>
</tr>
<tr>
<td>10.00-11.00</td>
<td>12</td>
<td>0</td>
<td>0</td>
<td>12</td>
</tr>
</tbody>
</table>

Frequency of visit of insect pollinators: Observations on insect pollinator’s visiting frequency showed that zucchini flowers begin to bloom around 07.30 pm and at that hour the insects begin to appear. The frequency of insect pollinators visit the research sites is quite varied. The highest visits obtained at 9:00-10:00 pm and after 10.00 pm the number of insects began to decline and almost no insects at 11:00 pm. The disappearance of the insects is likely due after 10:00 pm, zucchini flowers and flowers start to close again completely shut down at around 11:00 pm.

Based on Table 1, it appears that most pollinating insects in the area of study is of the type of bee is *Apis cerana*. According by Bradbear (2009), typically bees may visit flowers between 50-1000 flowers in a one-way trip and takes between 30 min to 4 h. Bees are the most important pollinators of plants in nature compared to wind, water and other insects. Many researchers have revealed that there is an increase in production if the number of bee colonies placed in the vicinity of the plant (Losey and Vaughans, 2006; Sanjerehei, 2014; Munyuli, 2014).

Plant pollination efficiency in zucchini: Zucchini fruits are formed (fruit set) is affected by the treatment of pollination. The number of flowers into fruit of a flower that were not covered by bag made of mesh more than the flowers that covered (Table 2). Flowers that are pollinated fruit growing characterized by perfect, otherwise the fruit produced from the pollinated flowers are not undeveloped. Fruit set was measured at each plant that is ready to harvest by counting or picking zucchini fruit ready for harvest. At one plant the zucchini, calculated the overall number of fruit growing and not growing.

Based on Table 2 shown comparison of two pollination values showed that the open field zucchini had the highest value. The results indicated that insect pollination gave the highest fruit set than wind pollination. This result reported also by Al-Abbadi (2010) that open pollination gave the highest yield than that close pollination on field grown tomatoes.

Meanwhile, the number (quantity), pollination treatment affects quality of fruit produced (size and weight of fruit zucchini). The fruit is formed of flowers left open (wind pollination). The fruit pollination by an insect is bigger and similar than the fruit of the flowers are not pollinated by an insect (close pollination). The illustration of fruit quality given in Fig. 3. Under open pollination naturally pollinated zucchini has strongly positive effect on the fruit quality (size and weight). Zucchini flowers were covered by bag mesh produce small fruit and the weight is also low (Fig. 3a), even the fruit will not be sold because its form is not in accordance with market demand. In contrast to the flowers that is not covered by bag mesh, the fruit produced bigger size and weight and in accordance with market demand (Fig. 3b).

Based on Table 3, it can be concluded that the zucchini plants including criteria is dependent upon insect pollinators. The size and weight will affect production. Such criteria based on criteria Klein *et al.* (2007) which classifies the plant’s dependence on insect pollinators, namely: (i) It is vital (essential) that the decline in production of 90% or more in the absence of insect pollinators, which means that the plant is in
Economic importance of insect pollinators: The existence of pollinating insects can affect the production of crops that depend on insect pollinators. Loss of insect pollinators causes decreased production or increased production costs. When no insect pollinators, the flowers will not be pollinated so that the crop will fail.

Factors dependence on insect pollinators is an indicator of the contribution of pollinators to the value of production per hectare. The results showed the economic contribution of pollinating insects to the value of farm production zucchini can be seen in Table 4.

Based on interviews with farmers to farm crops zucchini that is dependent upon the extent of the presence of insects (bees) in the location of the farm, the more bees are coming, the higher the production zucchini. If in a farming area there are a lot of bees, usually in a single zucchini plant there is a lack of fruit 1-2/handicapped or in a single zucchini plant can produce 20-25 fruits on the contrary, if the presence of insects is reduced, then the less good zucchini fruit growing lot or in one plant can produce 10-15 fruits. Reduced insect pollinators visit to farming areas likely to be caused by the use of pesticides. Vegetable farmers usually spray the plants 1-2 times a week. Agricultural intensification one pesticide use as directed impact on the population of insect pollinators. Decline in pollinating insect populations in ecosystems may lead to a decrease in crop production, vegetation cover, the extinction of a number of plant species and the degradation of ecosystem services and health. Based on the economic value of insect pollinators, the use of organic farming techniques, the use of pesticides and herbicides that are less toxic and highly selective can help preserve the level of species diversity of insect pollinators and pollination services which ultimately will increase the income of farmers.

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REFERENCES


Table 4: Value of zucchini fruit production resulting from pollination by insect

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dependence on insect pollination (%D)*</td>
<td>95</td>
</tr>
<tr>
<td>IDR average value (Q×(P-C))</td>
<td>90,000,000</td>
</tr>
<tr>
<td>Economic value of insect pollinators (IDR)</td>
<td>85,500,000</td>
</tr>
</tbody>
</table>

*D-values are from Klein et al. (2007)


