Asian Journal of Plant Sciences

ISSN 1682-3974

science alert

ANSInet
an open access publisher
http://ansinet.com

Asian Journal of Plant Sciences 14 (2): 84-88, 2015
ISSN 1682-3974

RESEARCH ARTICLE OPEN ACCESS

DOI: 10.3923/ajps.2015.84.88

Insects Pollination of Zucchini Farming in Indonesia and their Economic Importance

Mia Rosmiati, Ramadhani Eka Putra and Ahim Ruswandi
School of Life Sciences and Technology, Institut Teknologi Bandung, Jalan Ganesha 10, Bandung, 40132, Indonesia

ARTICLE INFO
Article History:
Received: August 13, 2015
Accepted: October 15, 2015

Corresponding Author:
Mia Rosmiati
School of Life Sciences and Technology,
Institut Teknologi Bandung,
Jalan Ganesha 10, Bandung, 40132,
Indonesia

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.

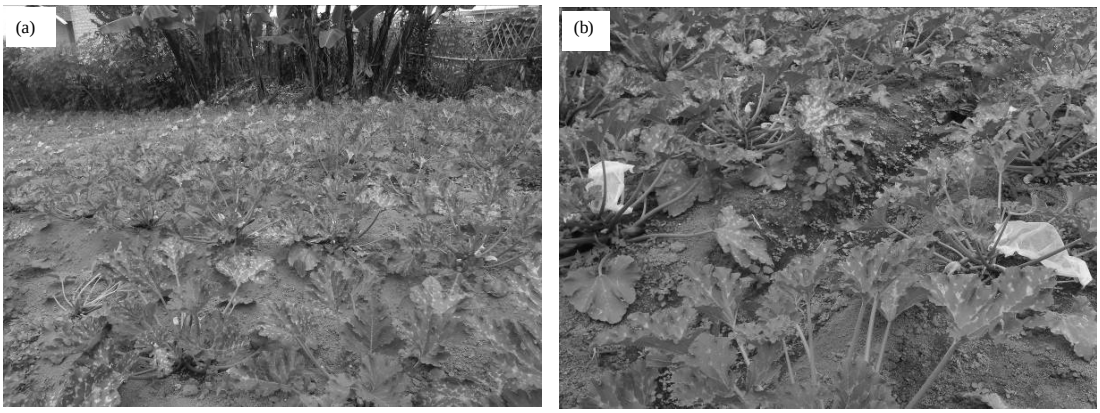

Fig. 1(a-b): Zucchini vegetable in the Farming Lembang, West Java-Indonesia

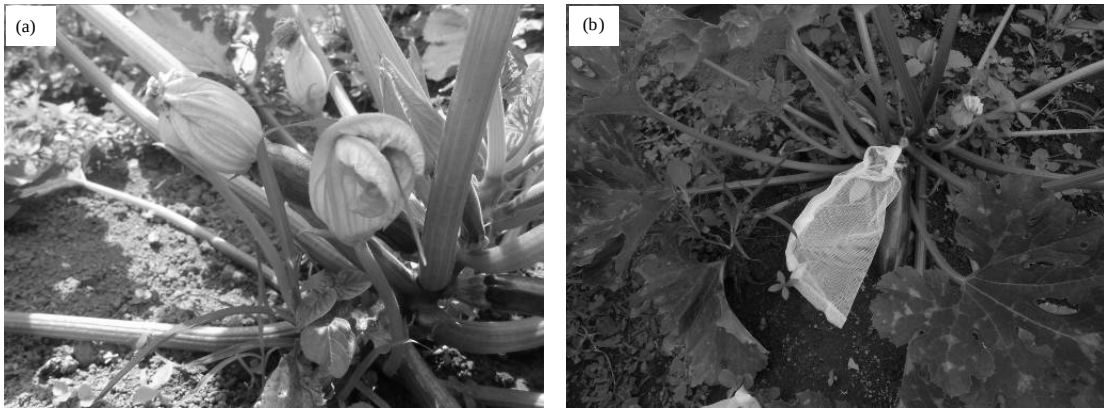

Fig. 2(a-b): Treatment of method insect pollination of zucchini farming, (a) Flowers with insect pollination and (b) Flowers with wind pollination

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:

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

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

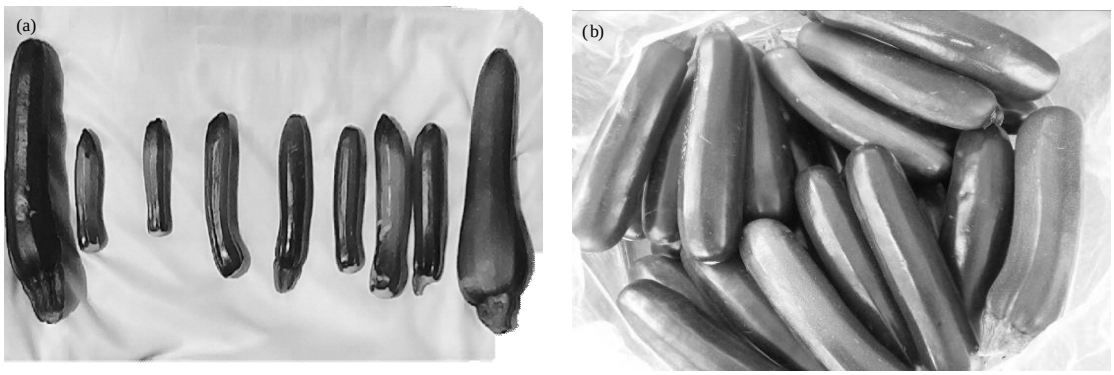

Fig. 3(a-b): Zucchini fruit quality for the both treatment, (a) Caged plant pollination and (b) Open plant pollination

Table 1: Visitation rate of bee pollinators during 3 days

	Visitation time (pm)		
Species bees	08.00-09.00	09.00-10.00	10.00-11.00
Apis cerana	34	60	12
Xylocopa sp.	3	4	0
Trigona sp.	14	20	0
Total	51	84	12

dominance of Apiformes as major flower visitor for most plants (Delaplane *et al*., 2000; Klein *et al*., 2007).

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 flower starts 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

Table 2: Effect of wind and insect pollination on pollination efficiency

Treatments	Numbers of flowers	Fruit number	Pollination efficiency
Wind pollination	20	1	5
Insect pollination	20	20	100

Table 3: Effect of treatment wind and insect pollination for each zucchini fruit

Treatment parameters	Wind pollination	Insect pollination
Length (cm)	12.00±1.69	23.65±2.08
Diameter (cm)	2.70±0.30	4.80±0.47
weight (g/fruit)	38.00±10.04	246.25±12.23

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

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

Parameters	Value
Dependence on insect pollination (%D)*	95
IDR average value (Q×(P-C))	90.000.000
Economic value of insect pollinators (IDR)	85.500.000

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

desperate need insect pollinators, (ii) high (great), namely the decline in production of between 40%≤x<90%, (iii) moderate (modest) i.e. a decrease of between 10%≤x<40%, (iv) Small (little), a decrease of 0<x<10% (v) no decrease and (vi) is not known, there are no available means of reference to draw conclusions about the dependence on pollinators.

Statistically, there are significant differences in terms of length, diameter and weight between wind and insects pollination ($p<0.05$).

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.

According Gallai *et al*. (2009), the value of production per unit of land area farm of insect pollinated plants four times greater than the plants that are not pollinated by an insect. So farmers can make more money and produce more nutritious foods if they are to farm crops of high economic value and pollination depend on insect pollinators. Klatt *et al*. (2014) stating that the pollination of plants has the potential to reduce food loss and waste are pollinated plants, thus contributing to global food security. Therefore, future research should focus pollination not only the results but also the effect on the quality of the crop. A more comprehensive understanding of how pollination can provide the benefits of global food security should lead to a more efficient crop production to help meet future food needs.

CONCLUSION

Under open pollinated zucchini has strongly positive effect on the fruit quality; fruits size and weight been extremely higher than those pollinated under screen pads. The average value of pollinator founded that insect pollinators almost exclusively bees responsible for almost IDR 85.5 million of zucchini fruits produced in the farming Lembang, West Java, Indonesia. This indicates that the prevention of the insect pollinators, the use of organic farming techniques, the use of pesticides and herbicides that are less toxic and highly selective can help to preserve the level of species diversity of insect pollinators and pollination services which ultimately will increase the income of farmers.

ACKNOWLEDGMENT

The author would like to thank Institut Teknologi Bandung (ITB), Indonesia for providing Research Grant of Capacity Building Program No. SITH. PN-6-8-18-2014 for this study.

REFERENCES

Al-Abbadi, S.Y., 2010. Open pollination efficiency on field-grown tomato compared with isolated under similar condition. Sarhad J. Agric., 26: 361-364.

Bradbear, N., 2009. Bees and their Role in Forest Livelihoods: A Guide to the Services Provided by Bees and the Sustainable Harvesting, Processing and Marketing of their Products. Volume 19 of Non-Wood Forest Products, Food and Agriculture Organization of the United Nations, Rome, Pages: 204.

Delaplane, K.S., D.R. Mayer and D.F. Mayer, 2000. Crop Pollination by Bees. CABI Publishing, Wallingford, UK., ISBN-13: 9780851997834, Pages: 352.

Gallai, N., J.M. Salles, J. Settele and B.E. Vassiere, 2009. Economic valuation of the vulnerability of world agriculture confronted with pollinator decline. Ecol. Econ., 68: 810-821.

Greenleaf, S.S. and C. Kremen, 2006. Wild bees enhance honey bees' pollination of hybrid sunflower. Proc. Natl. Acad. Sci. USA., 103: 13890-13895.

Hein, L., 2009. The economic value of the pollination service, a review across scales. Open Ecol. J., 2: 74-82.

Izadi, H., M.A. Samih and K. Mahdian, 2006. Identification and introduction of some Iran pollinator bees of Colletidae, Halictidae and Megachilidae (Hym: Apoidea). Commun. Agric. Applied Biol. Sci., 71: 621-624.

Kevan, P.G. and T.P. Phillips, 2001. The economic impacts of pollinator declines: An approach to assessing the consequences. Conserv. Ecol., Vol. 5.

Khaghaninia, S., Y. Guler and F. Dikmen, 2013. New records for the bee fauna of Iran (Hymenoptera: Apoidea). Zool. Middle East, 59: 319-325.

Klatt, B.K., A. Holzschuh, C. Westphal, Y. Clough, I. Smit, E. Pawelzik and T. Tscharntke, 2014. Bee pollination improves crop quality, shelf life and commercial value. Proc. Royal Soc. B: Biol. Sci., 281: 2013-2440.

Klein, A.M., B.E. Vaissiere, J.H. Cane, I. Steffan-Dewenter, S.A. Cunningham, C. Kremen and T. Tscharntke, 2007. Importance of pollinators in changing landscapes for world crops. Proc. Biol. Sci., 274: 303-313.

Klein, A.M., I. Steffan-Dewenter and T. Tscharntke, 2003. Bee pollination and fruit set of *Coffea arabica* and *C. canephora* (Rubiaceae). Am. J. Bot., 90: 153-157.

Kremen, C., R.L. Bugg, N. Nicola, S.A. Smith, R.W. Thorp and N.M. Williams, 2002. Native bees, native plants and crop pollination in California. Fremontia, 30: 41-49.

Losey, J.E. and M. Vaughan, 2006. The economic value of ecological services provided by insects. BioScience, 56: 311-323.

Morandin, L.A. and M.L. Winston, 2005. Wild bee abundance and seed production in conventional, organic and genetically modified canola. Ecol. Applic., 15: 871-881.

Morse, R.A. and N.W. Calderone, 2000. The value of honey bees as pollinators of US crops in 2000. Bee Cult. Magaz., 28: 1-15.

Munyuli, B.M.T., 2014. Social and ecological drivers of the economic value of pollination services delivered to coffee in central Uganda. J. Ecosyst., Vol. 2014. 10.1155/2014/298141

Ricketts, T.H., 2004. Tropical forest fragments enhance pollinator activity in nearby coffee crops. Conser. Biol., 18: 1262-1271.

Sanjerehei, M.M., 2014. The economic value of bees as pollinators of crops in Iran. Ann. Res. Rev. Biol., 4: 2957-2964.