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QUANTITY AND QUALITY OF CUCUMBER FRUIT RESULTED FROM VARIOUS METHODS OF POLLINATION

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ABSTRACT

Different methods of cucumber pollination can result in the differing effectiveness in fruit setting and, in turn, determine the final yield and fruit quality. This study aimed to compare the effect of pollination by *T. laeviceps* bees and other pollinating insects on cucumber production. The treatments tested included open pollination with the help of *T. laeviceps* and wild pollinating insects, human-assisted pollination, and pollination by wind. The indicators observed were the quantity and quality of the harvest including the shelf life of the fruit. The results showed that open pollination could increased the percentage of fruit set, normality, length, diameter, weight, and number of seeds. However, this study showed that there was no effect of pollination on the shelf life of cucumber.

Keyword: *pollinator, shelf life, stingless bee*

ABSTRAK

[KUANTITAS DAN KUALITAS BUAH MENTIMUN DARI BERBAGAI METODE PENYERBUKAN]. Metode penyerbukan mentimun yang berbeda dapat menyebabkan efektivitas yang berbeda dalam pembentukan buah dan, pada gilirannya, menentukan hasil akhir dan kualitas buah. Penelitian ini bertujuan untuk membandingkan pengaruh penyerbukan oleh lebah *T. laeviceps* dan serangga penyerbuk lainnya terhadap produksi tanaman mentimun. Perlakuan yang dilakukan yaitu penyerbukan terbuka dengan bantuan *T. laeviceps* dan serangga penyerbuk liar, penyerbukan dengan bantuan manusia, dan penyerbukan oleh angin. Indikator yang diamati meliputi kuantitas dan kualitas hasil panen termasuk umur simpan buah. Hasil penelitian menunjukkan bahwa penyerbukan terbuka dapat meningkatkan persentase pembentukan buah, kenormalan, panjang, diameter, berat, dan jumlah biji. Namun, pada penelitian ini menunjukkan bahwa penyerbukan tidak mempengaruhi umur simpan buah mentimun.

Kata kunci: *lebah tanpa sengat, penyerbuk, umur simpan*

INTRODUCTION

Pollination is the process of transferring pollen from the male flower to the female flower, so that fertilization will occur from this process. Pollination is an important role in seed formation which are used as a means of reproduction. Seeds are formed through the formation of fruit first that can be used by humans and animals (Widhiono, 2015). There are two types of pollination, self-pollination and cross-pollination. Both can occur on the same plant or different plants of the same species. Pollination can take place with the help of pollinating agents such as water, wind, humans, and animals (Azmi *et al*., 2017).

Bees are one of the group of insects that help pollinate various plants, causing bees to become an integral part of plant cultivation (Pateel & Sattagi, 2007). *Tetragonula laeviceps* is included in the group of pollinating bee that have high potential to increase agricultural production, because it is small, does not sting, has high adaptability to pressure and environmental changes, easy to handle, has high activity, and produces high propolis (Djajasaputra, 2010). According to Azmi *et al.* (2017), stingless bee can increase the quality and quantity of the cucumber harvest. According to Hasan (2015), pollination by bees affects the quality and quantity of cucumbers produced. Pollination with bees increased the number of normal fruit (100%) per plant, the number of seeds per fruit (77.61%), and the weight of cucumber seeds (28.57%). This also occurred in bitter melon, which showed a 75% increase in the number of fruit formed and increase the weight and number of seeds produced (Syahputra *et al*., 2016).

Cucumber (*Cucumis sativus* Linn.) belongs to the vegetable plant that propagates from the Cucurbitaceae family. In Indonesia, cucumber production data in 2017 and 2018 increased from 424 thousand tons to 433 thousand tons (BPS, 2019). Improved production data is also supported by the pollination process. Cucumber belongs to the group of monoecious plant. Pollination occurs in cross-sectional manner, where the male and female flowers are separated but still on the same plant (Pateel & Sattagi, 2007). Cucumber flower pollen has a sticky texture and high moisture content, so that it is easily to attach to the bodies of pollinating insects that visit cucumber flowers (Delaplane & Mayer, 2000). Therefore, this study aimed to compare the effect of pollination by *T. laeviceps* pollination and other insect pollinators on cucumber plant production.

MATERIALS AND METHODS

Time and Place of Research

The study was carried out in the experimental garden of the Department of Plant Protection, IPB University in Cikarawang Village, Dramaga, Bogor, from March to May 2020.

Design of Experiment

The research was conducted using a completely randomized design (CRD) consisting of 3 pollination treatments, namely open pollination with the help of *T. laeviceps* and wild pollinating insects (open pollination/ OP), human-assisted pollination (hand pollination/ HP), and wind-assisted pollination (wind pollination/ WP). Each treatment was repeated 7 times with the experimental unit in the form of beds. In each bed, there were 8 samples selected by simple random. The OP treatment application was carried out by introducing two colonies of *T. laeviceps* in the field and utilizing wild pollinators available in the land, while HP and WP treatments were carried out by covering them on female flowers. The covering uses oil paper for HP treatment and tile cloth for treatment of WP. This flower closure is done when the flowers are not yet fully bloomed, namely on the fourth day of flower appearance. When the flowers are fully bloomed, the application of HP treatment is carried out by manual pollination transferring pollen from male flowers to the stigma of female flowers. After that, the pollinated flowers are closed back to avoid pollination by insects and opened when the flowers have started to wilt. WP treatment application is carried out by leaving the flower closed until the flower withered.

Land Preparation and Planting

The research area used is 150 m^2 consisting of 21 beds measuring 4 x 1 m^2 with a height of 30 cm and the distance between the beds is 0.4 m. The beds are then covered with black silver plastic mulch and perforated for planting holes with a spacing of 50 x 60 cm with each bed consisting of two rows of planting. In each planting hole, 0.5 kg of manure was applied and ± 0.5 g of insecticide/nematicide with active ingredient carbofuran (3% G) was also applied to prevent soil insects and parasitic nematodes. The seeds that did not germinate were embroidered at 1 week after planting (WAP) to 2 WAP. Plant maintenance was carried out for the first time by applying NPK fertilizer at 3, 4, and 5 WAP. Furthermore, as a support for 2 days old cucumber plants which already grown vines, used a pole with 2 m length and tied by raffia

Measurement of Quantity and Quality of Harvest

The yield measured was the ripe cucumber in each treatment bed. For example, 5 cucumbers are used for each bed. Measurements include the percentage of fruit that is formed (fruit set), the percentage of fruit normalcy, fruit weight, fruit length, fruit diameter, and number of seeds (seed set) (Hasan, 2015).

The fruit set calculation is done by comparing the number of flowers that form fruit with the number of flowers that did not form fruit from the total flowers observed. In this case, the number of flowers observed is 5 for each sample plant. The calculation of the

percentage of fruit normalcy is done by comparing the number of normal fruit with the abnormal fruit. The criteria for normal cucumber fruit are straight fruit (Hasan, 2015). The calculation of the seed set was done by calculated the number of seeds formed on the cucumber.

Observation of Fruit Shelf Life

Observation of the fruit shelf life was carried out by storing cucumber at room temperature for 9 days. The observed variables were weight loss, level of hardness, and level of damage on days 3, 6, and 9. Measurement of weight loss was carried out by weighing the cucumber and calculated using the formula:

$$SB = \frac{W0-Wn}{W0} x\ 100\%$$

where SB is the weight loss (%), W_0 initial weight (g), and Wn final weight (g).

The observation of the level of hardness and the level of fruit damage used the scoring method as follows:

Table 1. Hardness score and damage

Score	Hardness[a]	Damage (%)[b]
0	-	0
1	Soft	1 - 5
2	Less loud	6 -10
3	Hard enough	11 - 15
4	Hard	16 - 20
5	Very hard	20 - 25
6	-	>25

Source : a Widyastuti & Aminudin (2013)

b Andriani *et al. (2018)*

Data Analysis

The data obtained from the measurement of the above variables were tabulated using Microsoft Excel 2013. Examination of the effect of pollination treatment on crop production was carried out using variance and SNK test with a significant level of 5%. This data analysis was performed using the Statistical Analysis System (SAS) for Windows version 9.4. Examination of the effect of pollination treatment on fruit hardness and damage was carried out using the Kruskal Wallis test and Dunn's test with a significant level of 5%. This analysis used the Statistical Package for Social Science (SPSS) program version 22 .

RESULTS AND DISCUSSION

Effect of Pollination on Quantity and Quality of Cucumber Fruit

Cucumber plants with OP treatment produced 53.93% fruit, HP treatment produced 46.79% fruit, and WP treatment produced 11.43% fruit from all flowers formed in each treatment. These results indicated that the percentage of fruit formed from OP and HP treatments was relatively the same, while the WP treatment was the lowest. Based on all of the fruits formed, the OP treatment produced normal fruit 88.57%, HP treatment 74.29%, and WP treatment 58.29%. These results indicated that the OP treatment formed more normal fruit than the WP treatment, but was relatively the same as the HP treatment (Table 2).

Cucumber plants with OP treatment could increase the quality and quantity of fruit compared to the WP treatment, but it was relatively the same as the HP treatment. According to Hasan (2015), cucumber plants whose pollination is assisted by bees can increase cucumber production. The difference in the quantity and quality of fruit from each treatment is related to the success of the pollination process. According to Faegri & Pijl (1971), insect pollinators can increase the quantity and viability of pollen from plants. Other wise, the success of pollination in the HP treatment is influenced by technical problems of pollination compared to the pollination process (Putra *et al*., 2017). Fruit formation in WP is associated with a decrease in pollen viability because anther in female flowers is not pollinated by pollen for several hours or several days (Kahriman *et al.,* 2015).

The Effect of Pollination on the Shelf Life of Cucumber Fruit

The results of the analysis of the effect of pollination on the storage capacity of cucumber showed that the three treatments were not significantly different. On the weight loss data, there was an increase in each observation. In addition, the level of fruit damage also increased with each observation. Another result, the level of fruit hardness in each observation decreased (Table 3).

Pollination on cucumber plants does not affect the shelf life of the fruit. However, on the observation each measurement parameter shows a change over time of observation. In general, the change in fruit quality was observed due to the respiration process. In addition, the main factor that affects changes in fruit weight loss is the transpiration process which causes the water content in the fruit to evaporate (Winarno, 2002).

Table 2. Indicator of quantity and quality of cucumber fruit in various pollination treatments

Indicators of Quantity and Quality of Results	Treatment[1,2]		
	OP	HP	WP
Fruit set *(%/plant)*	53.93 ± 9.00a	46.79 ±17.42a	11.43 ± 4.53b
Fruit normality (%/plant)	88.57 ± 15.74a	74.29±19.02ab	58.29 ± 22.79b
Fruit length (cm)	15.57 ± 1.15a	14.77 ±1.12a	12.86 ± 0.89b
Fruit diameter (cm)	4.16± 0.19a	3.97±0.32ab	3.72±0.22ab
Fruit weight (g)	126.94 ±12.33a	117.83 ± 23.81a	88.80 ± 15.20b
Seed set *(seed/fruit)*	258.20 ±38.98a	235.57 ± 32.45a	172.56 ± 13.94b

[1]The number after the ± sign represents the standard deviation.

[2]Numbers in a row followed by the same letter indicate no significant difference (SNK test, $\alpha = 5\%$).

Table 3. Indicator of cucumber fruit storage capacity in various pollination treatments

Fruit shelf life indicator	Day to	Treatment[1,2,3]		
		OP	HP	WP
Weight loss (%)	3	2.81 ± 1.98a	3.18 ± 1.07a	4.55 ± 1.78a
	6	7.56 ± 3.70a	7.61 ± 1.77a	11.10 ± 4.19a
	9	13.54 ± 9.58a	16.23 ± 7.59a	22.93 ± 12.29a
Hardness level	3	5.00a	5.00a	4.00a
	6	3.50a	3.50a	2.50a
	9	1.50a	3.00a	1.50a
Damage level	3	0.00a	0.00a	1.00a
	6	1.50a	1.00a	3.00a
	9	4.50a	1.50a	5.00a

[1]Means (weight loss) andmedian (hardness and damage level).

[2]The number after the ± sign represents the standard deviation.

[3] Numbers in a row followed by the same letter indicate no significant difference

(SNK/ Dunn test, a = 5%).

The decrease in the level of hardness in cucumber fruit occurs due to physiological processes that result in damage to the cell structure, cell wall composition, and intracellularity in the fruit and the presence of biochemical processes that involve degradation of water-insoluble pectin (protopectin) into water-soluble pectin resulting in cohesion between cell walls become decreased (Ali *et al.,* 2010). Damage to cucumber fruit occurs during storage, one of which is caused by biological processes such as pests and

plant diseases and is supported by contact with oxygen gas which causes these pests and diseases to grow (Rochayat & Munika, 2015).

Insect Pollination in Cucumber

Stingless bee (*T. laeviceps*) is relatively small, 4-6 mm long, shiny black in color (Figure 1a). Despite their small size, these stingless bees also have an important role in the pollination process. Besides *T. laevicep* bees, other pollinating insects found in cucumber plantations are *Apis cerana* and *Xylocopa confuse* (Fig. 1b and 1c). According to Indriani (2014), the dominant species of insect pollinating cucumber plants are *Apis cerana* and *X. confusa*. Bee *A. cerana* is a pollinating insect that is often found in various plants on agricultural land. In the field of observation, these bees were found from the beginning of the emergence of flower anthesis until the end of flowering (4-8 WAP). Susilawati (2016) also mentions that *A. cerana* is the dominant pollinating insect found in cucumber plantations from various types of landscapes. The foraging distance of *A. cerana* can be up to 500 m (Aryal *et al.,* 2016). On the other hand, the duration of visits to cucumber flowers was about 15.14 seconds/ flower (Hanyala *et al*., 2016).

Xylocopa confusa is a pollinating insect whose nest is located in wood, so this bee is called the carpenter bee. In the field of observation, these bees were found only at the beginning of the emergence of flowers. This bee has the characteristics of a relatively large body about 22-25 mm (Windarsih & Trianto, 2021), purple wings, hairy legs and thorax, and a black abdomen (Widhiono, 2015). The behavior in taking nectar is by moving the proboscis to the side of the flower, while pollen is taken using the forelegs and collected in the abdominal hair. When perched on a flower, this bee alights by opening its wings (Hasan 2015). The foraging distance of *X. confusa* is about 12 km from the nest depending on the number of wings hamuli (Roubik, 1989). According to Hasan (2015), the foraging rate of *X. confusa* was 12.55 flowers/minute, the duration of the visit was 4.78 seconds/flower, and the duration of the visit to plants was 17.93 seconds/plant.

CONCLUSIONS

Open pollination (OP) with the help of *T. laeviceps* and other insect pollinators can increase fruit set, normality, fruit length, fruit diameter, fruit weight and seed set. Another result, the pollination of cucumber plants does not affect the shelf life of fruit.

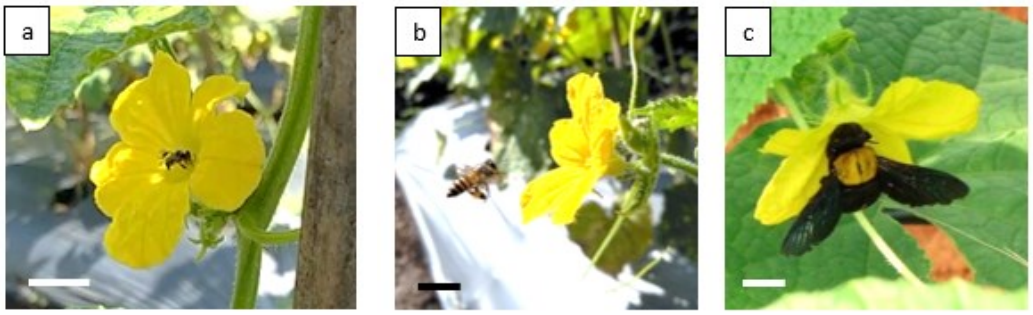

Figure 1 Insects pollinator on cucumber flower. Stingless bee *T. laeviceps* (a), honey bee *A. cerana* (b), and carpenter bee *X. confusa* (c). Description: white/black bar: 1

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