JERAMI (Indonesian Journal of Crop Science)

Volume 1, Issue 1, August 2018

http://jerami.faperta.unand.ac.id/index.php/Jerami-JIJCS

OPEN ACCESS

Research Article

Effect of Pollination Models on Yield of Red Pitaya (*Hylocereus polyrhizus*)

Renfiyeni Renfiyeni[1]*, Sudjijo Sudjijo[2], Helti Andraini[1] and Yagestina Safetri[1]

[1]Faculty of Agriculture, University of Mahaputra Muhammad Yamin, Solok – West Sumatera, Indonesia
[2]Research Center of Tropical Fruit Crops, Aripan, Solok – West Sumatera, Indonesia

Abstract

Background and Objective: Red pitaya is getting more popular in Indonesia recently as one of high antioxidant sources with a promising economic value. However, the production of this plant is restricted by low success percentage of its natural pollination and self incompatibility problems. Therefore, artificial pollination is required to overcome these problems and increase its yield. This study was aimed to evaluate the effect of pollination models towards the yield of red pitaya. **Materials and Methods:** This study was conducted using block randomized design with three pollination models applied into nine groups. Pollination models used were open pollination (P1), hand-self-pollination (P2) and hand-cross pollination (P3). Several floral-related parameters, including the elongation of flower bud, diameter of blooming flower, length of stigma, number and length of anthers, were assessed. Effect of different pollination models was also observed through some yield-related parameters, such as fruit weight, fruit diameter, fruit length, harvesting age and number of fruit sets. **Results:** This study revealed that hand cross pollination produced the best yield performance showing 541.1 gram of fruit with 11.5 cm in length and 8.66 cm in diameter. Harvesting age and number of fruit sets showed no significant difference among those three pollination models.

Key words: Flowers, fruits, pollination, red pitaya, yields.

Citation: Renfiyeni Renfiyeni, Sudjijo Sudjijo, Helti Andraini and Yagestina Safetri, 2018. Effect of Pollination Models on Yield of Red Pitaya (*Hylocereus polyrhizus*). Jerami Indonesian J. Crop Sci., 1 (1): 19-24. DOI: 10.6084/m9.figshare.7028021.

Corresponding Author: Renfiyeni Renfiyeni, Faculty of Agriculture, University of Mahaputra Muhammad Yamin, Solok 27317, West Sumatera, Indonesia. Email: renfiyeni@yahoo.com.

Received: August 19, 2018 **Accepted:** August 27, 2018 **Published:** August 31, 2018

Competing Interest: The authors have declared that no competing interest exists.

Introduction

Red pitaya or dragon fruit (*Hylocereus polyrhizus*) is firstly recognized as an ornamental crop in several Asia countries, such as Taiwan, Vietnam and Thailand. As the time passed, people recognized that it was potential to cultivate and economically profitable (Tjitrosoepomo, 2007). Red pitaya contains high vitamin C with 80 % water. Besides, this fruit also contains fiber, calcium, iron and phosphor that are beneficial to cure the hypertension. This red-fleshed fruit is preferrable due to its high carotenoid content which is good to maintain the eyesight health. Its phytochemical contents provide multivarious health benefits, such as reducing the cancer risk, balancing the blood sugar and pressure, cleansing the blood, strengthen the kidney, maintaining the skin and liver health, improving the brain power and eyesight, reducing the symptom of fluor albus and canker sore as well as controlling the cholesterol level (Simatupang, 2007; Mahadianto, 2007).

Considering the agroclimate and soil condition of Indonesia regions, red pitaya is supposed to grow well in Indonesia. As the demand of this commodity is increasing, the development of this fruit into an agribusiness is highly promising. Additionally, the market for this commodity is broadly available indicating its prospective opportunity to develop in Indonesia (Departemen Pertanian, 2005).

In contrast, the production of red pitaya is restricted by its low pollination effectivity leading to low fruit production. Naturally, the capability of red pitaya in forming the fruit set is very low due to high number of flowers falling occurrence. Moreover, the far distance between stigma and anther is regarded as one of the main obstacles inhibiting the success of its natural pollination. Therefore, artificial (cross) pollination is required to increase the fruit set formation. Moreover, artificial pollination is considered as a well-known yet simple method to improve the genetic variation among species (Tjitrosoepomo, 2007). However, the application of artificial pollination for red pitaya is rarely reported, hence the effect of this artificial pollination toward the fruit yield is recommended to be investigated. This present study was aimed to identify the pollination models stimulating optimum yield production of red pitaya.

Materials and Methods

The experiment was conducted using block randomized design in experimental garden of Research Center of Tropical Fruit Crops in Aripan – Solok from April to August 2016. Ten plants of red pitaya at two years of age were used in each pollination model. This experiment used three models of pollination, as followed open pollination, self pollination and cross pollination.

Flower buds were labelled at one week after flower formation to determine the flowers used for each pollination type. Pollination was then carried out four week later. As the flower anthesis occurred at midnight, pollination was performed at 1 am. For self pollination, pollen was emasculated from a flower and purposively placed on its own stigma. In contrast, cross pollination was conducted by placing pollen on the stigma of the neighboring flowers. All pollinated flowers were then bagged to avoid the occurrence of another pollination afterwards.

Pollination efficacy was further assessed after the fruit harvesting generally occurred at 28 to 33 days after flowering. Fruit was picked by cutting at the fruit edge using sickle. Several fruit quality parameters were evaluated, including fruit weight, fruit length, fruit diameter, harvesting age and fruit set formation. Value of fruit set formation was determined using this following formula:

$$\text{Fruit set rate (\%)} = \frac{\sum \text{Hf}}{\sum \text{If}} \times 100\ \%$$

where *Hf* indicated total number of fruitlets and *If* indicated total number of flowers. To support the data of yield-related parameters, other parameters were also evaluated, such as bud length, opened flower diameter, stigma lobe number and length as well as filament length. All collected data were analyzed statistically using one-way anova and significance among treatments was further assessed using Duncan's New Multiple Range Test (DNMRT) with a $p<0.05$.

Results

Flower Development before Pollination

Flower characteristics affected greatly to the success of pollination in all plants. At the beginning of its emergence, flower of red pitaya exhibited small elliptical shape with spherical button and was covered by small green and red edge pericarpel (Fig. 1). According to various parameters, there were no significant differences in floral morphological characteristics between flowers assigned for each pollination type (Table 1). It thus indicated the sample uniformity so that the differences resulted after the pollination was fully caused by the effect of pollination types.

Table 1. Morphological characteristics of assigned flowers for each pollination type.

Characteristics	Pollination Types		
	Open pollination	Self pollination	Cross pollination
Bud length (cm)	30.68	30.50	30.76
Diameter of opened flowers (cm)	27.63	27.43	27.78
Length of stigma lobe (cm)	25.96	25.91	26.11
Number of filament	1043.18	1043.16	1045.14
Filament length (cm)	18.71	19.76	19.83

Effect of Pollination Types on Fruit Production

Difference in pollination types affected significantly the characteristics of resulted fruits, but showed no effect on fruit set rate and harvesting age (Table 2). Fruits resulted from cross-pollinated flowers exhibited heaviest (541.11 g), longest (11.52 cm) and thickest (8.66 cm) fruit (Table 2). These results suggested that artificial cross pollination enhanced the efficacy of fruit formation. Although number of fruit set formed among pollination types was insignificantly different, but the quality of resulted fruit differed significantly.

Discussions

Physiologically, floral development in red pitaya was dependent on light availability. Light played a vital role in stimulating the flower to open. At the age of 4 weeks, flowers got bloated in the afternoon (Fig. 1) before anthesis where light was highly required to induce the opening of the flowers. As mentioned by Kristanto (2003), a 30 cm flower bud of red pitaya would bloom in the evening due to the light stimulation at noon that triggered the anthesis. The flower opening was began from the outer cream petal followed by the opening of inner petal. Once it opened completely around midnight, the bell-shaped flowers would reveal its yellow pollen that ready to be pollinated onto stigma. Flower diameter could reach 25-30 cm when it was completely opened (Lemke, 2007).

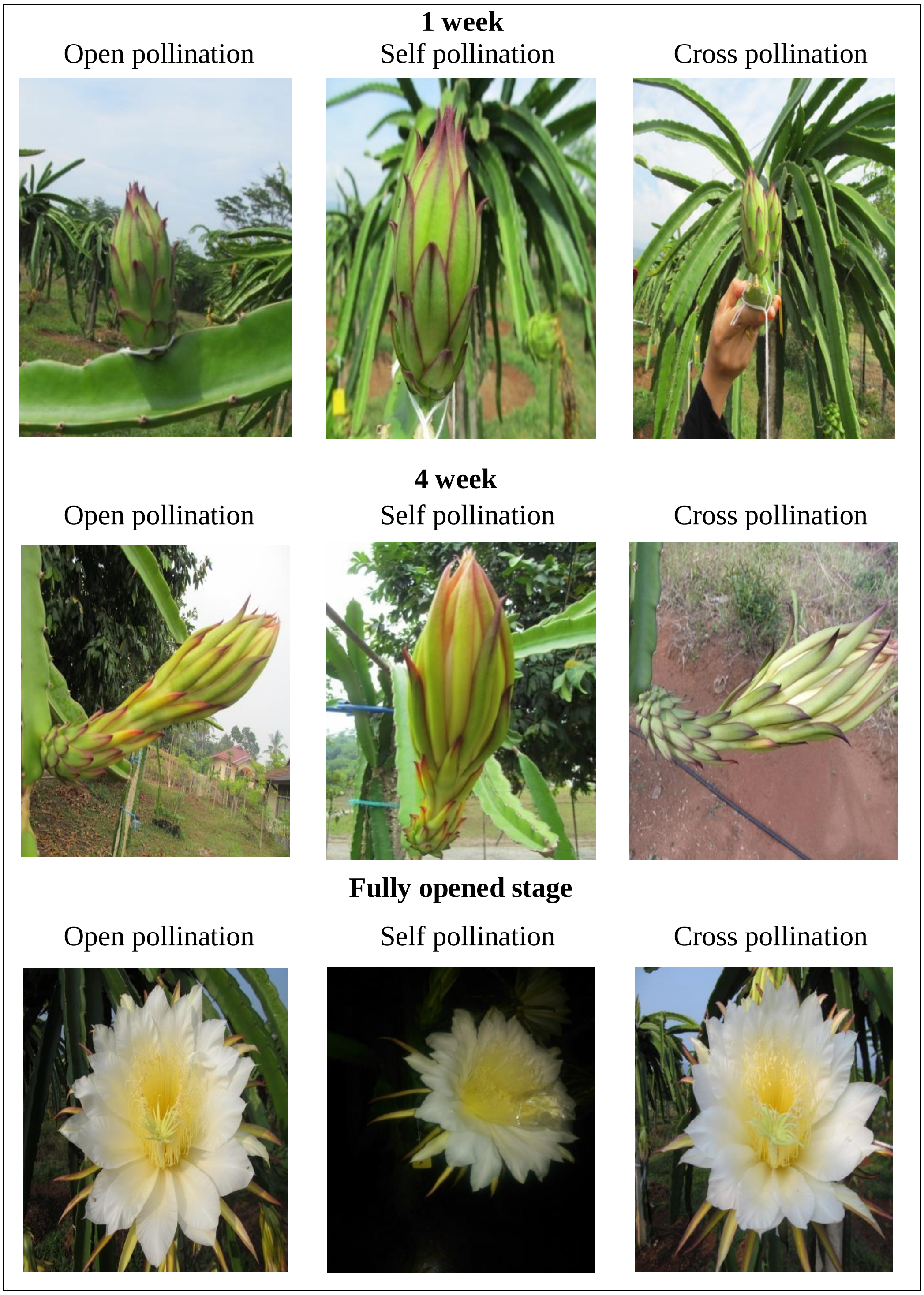

Figure 1. Visual of red pitaya flowers at different time periods.

Flower size was predicted to affect the characteristic of stigma lobe. The bigger the flower diameter, the longer the stigma lobe. The length of this stigma lobe determined the success of pollination. Naturally, red pitaya flowers had stigma located higher than its anther thus inhibited the natural self-pollination. This condition caused the pollen become unable to reach and attach to the stigma or so-called as self incompatibility commonly caused by genetic factors (Ruwaida, 2007). Due to this reason, pollination of this plant should be supported by humans and insects as pollinator or by performing an artificial pollination to maximize its fruit formation (Merten, 2003). Flower size also affected the number of pollens as the number of filaments also increased. The abundance of pollens is the main prerequisite to achieve better result in cross pollination (Widiastuti and Palupi, 2008).

Table 2. Morphological characteristics of fruit resulted from each pollination type.

Characteristics	Pollination Types					
	Open pollination		**Self pollination**		**Cross pollination**	
Fruit weight (g)	427.88	c	485.88	b	541.11	a
Fruit length (cm)	10.66	c	11.01	b	11.52	a
Fruit diameter (cm)	7.80	c	8.35	b	8.66	a
Fruit set rate (%)	94.28		98.09		96.19	
Harvesting age (days after anthesis)	30.11		30.00		30.11	

Numbers in the same row followed by the same lowercases were insignificantly different according to DNMRT with a $p<0.05$.

Pollination and fertilization processes are two correlated steps whose the success of both processes depend on the compatibility of pollen and stigma. Pollination is considered success when pollens attach successfully onto the stigma and germinate. This germinated pollen will elongate downward and enter the stigma lobe to reach the ovary until its end can attach the ovule. The mature ovary will become the fruit and mature ovule will become the seeds (Darjanto and Satifah, 1990).

An effective pollination determines the quality of resulted fruits. As natural pollination of red pitaya had been reported as an ineffective pollination, the utilization of artificial or cross pollination was highly recommended to enhance the efficacy of pollination and fertilization processes. As seen in Table 2, open (natural) pollination resulted in smaller fruit size and weight compared to cross pollinated ones indicating less optimal fruit formation. Pudjogunarto (2001) stated that artificial pollination enabled the pollen to fall onto stigma evenly. This condition determined the fruit development since pollen hormones would trigger the embryo growth. The expected fruit development was depended mainly by amount of pollens falling onto stigma during artificial pollination.

The fruitset rate obtained in this study showed that pollination types did not correlate to this parameter, although the fruit performances differed significantly (Table 2). The fruitset rate was determined by various factors, including the floral density. The denser and closer the flowers, the bigger the competition for pollination leading to flower withering. Floral density is recommended to reduce so that the nutrients competition among flowers can be minimized. Fruit development is influenced by internal (genetic) and external factors (rainfall, light intensity and pollen availability). Failure in fruit development may occur due to the incompatibility between pollen and stigma regulated by environmental factors and ineffective pollination (Gunawan, 2002).

Conclusions

Cross pollination exhibited higher fruit performances compared to open and self pollination marked by the highest weight (541.11 gram), diameter (11.52 cm) and length (8.66 cm) of fruit. No significant differences recorded on harvesting age and fruitset rate among pollination types. It was suggested to evaluate critical factors influencing pollination success to achieve the optimal conditions resulting in higher fertilization efficacy.

References

Darjanto dan Satifah, S., 1990. Pengetahuan Dasar Biologi Bunga dan Teknik Penyerbukan Silang Buatan. PT Gramedia Pustaka Utama. Jakarta.

Departemen Pertanian, 2005. Pengembangan Agribisnis Buah Naga (*Dragon Fruit*) Indonesia dalam Mencapai Pasar Ekspor. *http://www.bisnis.com*. Accessed on 3rd April 2016.

Gunawan, L. W., 2002. Budidaya Anggrek. Penebar Swadaya. Jakarta.

Guntara, I., 2007. Petani Deli Serdang Mulai Kembangkan *Dragon Fruit*. *http://www.medanbisnisonline.com/rubrik.php?p=96877&more=1*. Accessed on 3rd April 2016.

Kristanto, D., 2003. Buah Naga Pembudidayaan di Pot dan di Kebun. Penebar Swadaya. Jakarta.

Lemke, C., 2007. *Hylocereus undatus: Night-Blooming Cereus*. Department of Botany and Microbiology, University of Oklahoma. [Dissertation].

Mahadianto, N., 2007. Budidaya Buah Naga (*Dragon Fruit*). *http://agribisnis.deptan.go.id.* Accessed on 3rd April 2016.

Merten, S. 2003. A Review of *Hylocereus* Production in USA. http://www.jpacd.org/V5P98-105.pdf. Accessed on 3rd April 2016.

Pudjogunarto, W. S., 2001. Studi Penyerbukan pada Dua Fase Pemasakan Bunga Betina dengan Campuran Tepung Sari-Tepung Tapioka terhadap Hasil Salak Lawu (*Salaca edulis* REINW). Jurnal Agrosains, 3 (1), pp 12-18.

Ruwaida, I. P., 2007. Keserasian Silang pada Tanaman Buah Naga (*Hylocereus sp.*). Accessed on 3rd April 2016.

Simatupang, L., 2007. Buah Naga Segar dan Nikmat. *http://food_details.php.* Accessed on 3rd April 2016.

Tjitrosoepomo, G., 2007. Morfologi Umum Buah Naga *(Hylocereus polyrhizus)*. *http://id.wikipedia.org*. Accessed on 3rd April 2016.

Widiastuti, L., Tohari dan Sulistyaningsih, E., 2005. Pengaruh Intensitas Cahaya dan Kadar Dominsida terhadap Pembungaan dan Kualitas Tanaman Krisan dalam Pot. Jurnal Agrosains, 18 (3), pp 315-326.

Widiastuti, A dan Palupi, E. R., 2008. Viabilitas Serbuk sari dan Pengaruhnya terhadap Keberhasilan Pembentukan Buah Kelapa Sawit (*Elaeis guineensis* Jacq.). www. biotek.lipi.go.id/perpus/index.php?p=show. Accessed on 3rd April 2016.