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Research Article

Influence of Pollination Time and Flower Proportion on the Success Rate of Pollination and Yield of Melon Varieties (*Cucumis melo* L.)

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Abstract

Background and Objective: The success rate of pollination depend on receptive of stigma, pollen viability, pollination time and amount of pollen to be pollinated. The availability of pollen in one male flower with good viability is expected to pollinate more than one female flower. This research is aimed to determine the success rate of pollination of some melon varieties through the pollination time and the proportion of flower and to determine the difference in several yield characters. **Materials and Methods:** The experimental design in this research used a nested design with 3 hybridization sets of melon varieties (ME×ME, ME×MD and ME×GL). First factor was pollination time (W) divided into 3 levels, namely W1 = 6.00-7.00 am; W2 = 8.00-9.00 am; W3 = 10.00-11.00 am. Second factor was proportion of flower (P) divided into 3 levels, namely P1 = 1♀:1♂, P2= 2♀:1♂ and P3= 3♀:1♂. The implementation of P factor within W factor was considered in 2 blocks. The success rate of pollination calculation and yield characters was determined. **Result:** The highest percentage for the success rate of hybridization was at W3P1 and the best hybridization set through W and P treatment, for all yield characters, was at hybridization set of ME×GL varieties. The yield characters included fruit diameter, fruit length, flesh thickness and total soluble sugar. **Conclusion:** There was a significant difference on the success rate of hybridization in all hybridization sets (ME×ME, ME×MD and ME×GL). Based on the nested design, the highest percentage for the success rate of pollination in all hybridization sets was at W3P1 (100%), while the lowest percentage was at W1P3 (55.56%).

Key words: Hybridization, pollination, fruit diameter, fruit length, flesh thickness and total soluble sugar

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

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Melon (*Cucumis melo* L.) is a horticultural plant that belongs to the *Cucurbitaceae* family. Melon fruit is sweet and juicy and it causes melons to become one of the favourite fruit in the world¹. In Indonesia, the level of melon consumption per capita per week by the Indonesian people since 2014-2019 continues to increase. The consumption level² in 2014 reached 0.4, 0.8 kg in 2017 and might be reached 1-1.5 kg in 2019.

Melon has an economically important value. However, melon production in Indonesia is still low³. Melon production is a little bit difficult to be maximized in Indonesia because melon is subtropical commodity⁴. Another factor is the limited use of superior seeds. The price of superior seeds which are relatively expensive becomes an obstacle in melon farming system^{5,6}. One of the methods to increase melon seed production is by conducting the artificial pollination⁷⁻⁹.

Pollination is simply the movement of pollen from the male organ of flowers to the receptive female of flowers of the same or different plants^{10,11}. The failure of artificial pollination and melon formation is still quite high. This is because the formation of melon seeds and fruit depends on the receptive stigma, pollen viability and the time of pollination^{12,13}. The amount of pollen used in the artificial pollination process can also affect the success of pollination. The availability of pollen in one male flower with good viability is expected to pollinate more than one female flower under optimum conditions¹⁴.

The study to determine the success rate of hybridization in melon by using two factors, pollination time and flower proportion, male to female flowers, had been reported by Respatijart *et al.*¹⁵. However, in this previous study, the different times of pollination had been implemented in the same day or one period of time. Therefore, it is evidence to study the success rate of pollination of melon varieties by using similar treatments by approaching using another experimental design such as nested design which is the pollination time treatment would be divided into three periods of time in function of days.

This research is aimed to determine the success rate of pollination and the differences in several yield characters of all melon hybridization sets in some melon varieties through the pollination time and the flower proportion treatments based on nested design.

MATERIALS AND METHODS

Study area: This research was conducted on January-July, 2019 at Greenhouse of Faculty of Agriculture, Brawijaya University, Malang, Indonesia. Plant materials were 3 melon

varieties (Melindo (ME), Madesta (MD) and Glamour (GL)) and the other materials such as soil, compost, rope, polybags, fertilizer, pesticide, paper, cotton, alcohol 70% and label. The tools were used are the tray, cutter, tweezers, knapsack sprayer, ruler, analytical scale, refractometer Brix, callipers, stationery and camera.

Hybridization treatments: The plants were arranged based on the nested design with 2 replications. Hybridization sets for all melon varieties were ME (♀) × ME (♂), ME (♀) × MD (♂) and ME (♀) × GL (♂). This research used a nested design. First factor was pollination time (W) with 3 levels, namely W1 = 6.00-7.00 am; W2 = 8.00-9.00 am; W3 = 10.00-11.00 am. The second factor was the proportion of flower (P) with 3 levels, namely P1 = 1 ♀:1 ♂, P2 = 2 ♀:1 ♂ and P3 = 3 ♀:1 ♂. The implementation of P factor within W factor was considered in 2 blocks.

Success rate of pollination calculation: The percentage of the success rate of pollination was calculated by the formula (Acquaah¹⁶):

$$\text{Success rate of pollination (\%)} = \frac{\text{Fruit formed}}{\text{Pollinated female flowers}} \times 100(\%)$$

Yield characters: The observation of yield characters included fruit weight, fruit diameter, fruit length, flesh thickness and total soluble sugar. Total soluble sugar was measured by refractometer Brix.

Statistical analysis: The data obtained from the percentage of the success rate of pollination and yield characters were analyzed through the analysis of variance (ANOVA). The differences between the means were compared using the least significant difference (LSD) test ($p < 0.05$).

RESULTS

Percentage of success rate of pollination: Based on Table 1, the highest percentage was at W3P1 (100%), while the lowest percentage was at W1P3 (55.56%), for the success rate of pollination in all hybridization sets based on nested design.

Table 2 showed the mean square value of the success rate of pollination. The pollination time and the proportion of female to male flower were not significantly different in the ME × ME and ME × MD hybridization sets. The treatment of the proportion of flower showed very significant for the ME × GL hybridization set, but the treatment of pollination time for ME × GL was not significantly different.

Table 1: Percentage of success rate of pollination among the treatments in all hybridization sets

		♀ ME × ♂ ME		♀ ME × ♂ MD		♀ ME × ♂ GL		Mean (%)
Treatment		1	2	1	2	1	2	
W1	P1	100	0	100	100	100	100	83.33
	P2	100	100	100	50	50	100	83.33
	P3	66.67	100	33.33	33.33	66.67	33.33	55.56
W2	P1	100	100	100	0	100	100	83.33
	P2	100	100	50	50	50	50	66.67
	P3	100	100	100	100	66.67	33.33	83.33
W3	P1	100	100	100	100	100	100	100
	P2	100	100	50	100	50	50	75
	P3	33.33	33.33	100	66.67	100	100	72.22

ME: Melindo variety, MD: Madesta variety, GL: Glamour variety, W1: Pollination at 6.00-7.00 am, W2: Pollination at 8.00-9.00 am, W3: Pollination at 10.00-11.00 am

Table 2: Mean square of percentage of success rate of pollination among the treatments in all hybridization sets

	Treatments		
Set of hybridization	W		P (P within W)
ME×ME	987,68 ^{ns}		1419,86 ^{ns}
ME×MD	663,65 ^{ns}		1419,83 ^{ns}
ME×GL	416,67 ^{ns}		1527,78 ^{**}

ME: Melindo variety, MD: Madesta variety, GL: Glamour variety, W: Treatment of pollination time, P: Treatment of flower proportion, Ns: Non significant, **Significant at p<0.01

Table 3: Success rate of pollination percentage and its LSD notation for ME X GL hybridization

Treatments	Success rate of hybridization (%)
W1	
P1	100 ^b
P2	75 ^{ab}
P3	50 ^a
W2	
P1	100 ^b
P2	50 ^a
P3	50 ^a
W3	
P1	100 ^b
P2	50 ^a
P3	100 ^b
LSD 5%	36,61

Treatments denoted by the same letter within a column are not significantly different (p≤0.05) according to LSD test, W1: Pollination at 6.00-7.00 am, W2: Pollination at 8.00-9.00 am, W3: Pollination at 10.00-11.00 am, P1: Female and male flowers proportion at 1♀: 1♂, P2: Female and male flowers proportion at 2♀: 1♂, P3: Female and male flowers proportion at 3♀: 1♂

Table 4: Mean square of yield characters among the treatments in all hybridization sets

Yield character	Set of ME × ME		Set of ME × MD		Set of ME × GL	
	W	P	W	P	W	P
Fruit weight	2.41 ^{ns}	1.64 ^{ns}	1.30 ^{ns}	0.77 ^{ns}	2.05 ^{ns}	0.36 ^{ns}
Fruit diameter	0.81 ^{ns}	0.96 ^{ns}	2.66 ^{ns}	1.64 ^{ns}	131.17 ^{**}	27.60 ^{**}
Fruit length	0.81 ^{ns}	0.89 ^{ns}	2.22 ^{ns}	1.61 ^{ns}	194.86 ^{**}	51.04 ^{**}
Flesh thickness	0.27 ^{ns}	0.86 ^{ns}	1.78 ^{ns}	1.24 ^{ns}	82.00 ^{**}	14.27 ^{**}
Total soluble sugar	9.26 ^{**}	0.88 ^{ns}	5.93 [*]	1.74 ^{ns}	56.19 ^{**}	3.44 [*]

ME: Melindo variety, MD: Madesta variety, GL: Glamour variety, W: Treatment of pollination time, P: Treatment of flower proportion, Ns: Non significant, *Significant at p<0.05, **Significant at p<0.01

Due to the significant difference of the success rate of pollination in ME × GL hybridization set, through the treatment of proportion flower within pollination time (P within W), Table 3 provided the percentages for the success rate of pollination completed by LSD test values.

In this table, only W3 had more than one P that reached 100%, included W3P1 and W3P3.

Yield characters: Based on Table 4, the treatment of pollination time showed a significant difference at the total

soluble sugar on all hybridization sets. Treatment of pollination time and proportion of flower showed a significant difference for 3 characters included fruit diameter, fruit length and flesh thickness on ME×GL hybridization set. While those 3 characters were not significantly different on ME×ME and ME×MD hybridization sets.

DISCUSSION

In this research, the highest percentage for the success rate of pollination was at W3P1 which is not in agreement with the result from the previous study¹⁵. In the previous study, the highest percentage of the success rate of pollination was at W1P1. The different results might be caused by the different method to apply the pollination time. In this research, the W1, W2 and W3 treatments were applied in the function of days based on the nested design it means that W1, W2 and W3 were applied in different period of week (1-2 weeks, respectively). In the other hand, the previous study had conducted the treatments of pollination time, W1, W2 and W3, in the same day without any nested design.

This research used a nested design where W factor was an independent factor of the proportion of flowers. The implementation of W1, W2 and W3 had been applied in a different season. The rainfall intensity was high in the period of W1 and W2 which caused wet pollen. According to Burke¹⁷, the hybridization on cotton flower failed because used wet pollen. The wet pollen had broken and cannot germinate. Bots and Mariani¹⁸ explained that the pollen on *Brassica napus* which has been collected after rain will decrease the rate of germination.

According to Shafique *et al.*¹⁹, date palm flower that the amount of pollen used in pollination was not significantly affect to fruit weight. However, if the amount of pollen is not enough to pollinate the stigma, the fruit will be abnormal or small in size²⁰. These reports are in accordance with the result in this study where the characters of fruit diameter, fruit length and flesh thickness were not significantly different on the hybridization set of ME×ME and ME×MD. In the other hand, those yield characters were significantly different in the hybridization set of ME×GL. The different result among the hybridization sets might be affected by a different pollen source. Shafique *et al.*¹⁹ added that different pollen source has a different quality of pollen viability, percentage of germination and genetic structure. Thus, it can be affected to fruit formed process.

The proportion of one female and one male (P1) has caused stigma in female flowers got more pollen compared with treatment P2 and P3. Vidal *et al.*²¹ reported that the need

for the amount of pollen per ovule is influenced by the pollen viability. The amount of pollen is needed in large quantities if the pollen viability has decreased quality. Rezazadeh *et al.*²² worked in date palms had reported that the source of pollen has an effect on success in fruit formation. Different fruit characters can be caused by pollen viability and the development of different pollen tubes.

Based on the research of Pilgrim and Petersen²³, total soluble sugar in fruit (%) influenced by weather (dry and rain). Cui-hua *et al.*⁵ conducted the research by applying the treatment of watering with 15 days interval on melon plants had the highest of total soluble sugar than the other watering treatment such are 10 days and 7 days interval. Melon plants in this research, at W3 period, exposed to powdery mildew and downy mildew disease which caused the growth of plants at un-optimum conditions. In addition, according to Labeda and Cohen²⁴, cucumber plants exposed to fungi disease can cause damage to plants until crop failure up to 80%.

CONCLUSION

It could be concluded that the treatment of pollination time and the proportion of flowers were successfully applied to determine the success rate of pollination in all hybridization sets of melon varieties (ME×ME, ME×MD and ME×GL) based on nested design. The highest percentage for the success rate of pollination in all hybridization sets was at W3P1 (100%), while the lowest percentage was at W1P3 (55.56%). Besides, the hybridization of ME×GL was the hybridization set that affects the significant difference in several yield characters, included fruit diameter, fruit length, flesh thickness and total soluble sugar, through pollination time and the proportion of flower treatments.

SIGNIFICANCE STATEMENT

This study discovers the method of hybridization by considering the treatments of pollination time and proportion the female to the male flower that can be beneficial for plant breeder and agronomist to increase the success rate of pollination in melon. Therefore, this study will help the researcher to uncover the critical areas of low production of melon fruit and seed that many researchers were not able to explore.

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