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Effect of pollination time and proportion of females flowers to males flowers in yield and seed quality of melon (*Cucumis melo* L.)

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Melon seed production is influenced by time maturity of male flowers and female flowers. Availability of male flowers and female flowers also affect the results of melon seeds. This study aimed to determine the effect of pollination time and the proportion of male flowers to the female flowers on the yield and quality of melon seeds. The research was conducted in the Jatimulyo village, District Lowokwaru, Malang from February to May 2017. The plant was randomly arranged. The treatment were the pollination time and proportion of flowers. Pollination time consisted of three levels, namely (W1) at 6:00 to 7:00 a.m., (W2) at 08:00 to 09:00 a.m., and (W3) at 10:00 to 11:00 a.m. (Indonesian time). Proportion of male to female flowers consisted of three levels, namely P1 = 1 ♀: 1 ♂, P2 = 2 ♀: 1 ♂, and P3 = 3 ♀: 1 ♂. The result showed that pollination time gave significant difference on weight of fruit, length of fruit, number of seed per fruit, weight of seed, percentage of filled seed, weight of 100 seeds, synchronization of germination, and percentage of germination. The proportion of male to female flowers showed the significant effect of the weight of fruit, length of fruit, number of seeds, weight of seed per plant, percentage of filled seed, weight of 100 seeds, synchronization of germination and percentage of germination. There was an interaction between the proportion of female flowers with male flowers and pollination time on number of seed per plant.

Keywords: Melon, Pollination Time, Seed Quality, and The proportion of Male-female Flowers

INTRODUCTION

Melon (*Cucumis melo* L.) is one type of fruit from the family Cucurbitaceae that are widely consumed in fresh condition. Fresh Melon (*Cucumis melo* L.) contains 90% water and 10% carbohydrates. Melon (*Cucumis melo* L.) have many nutrients. Melon also contains vitamins A, C, D, K, *β*-carotene and minerals such as potassium, magnesium, phosporus, sodium, selenium, and calcium (Daryono, Wibowo, and Hanini, 2016). Melon productivity in Indonesia since 2010 – 2014 continues to increase. In 2010, melon production reached 85,861 tons and in 2014 the production of melon increased to reach 150,347 tons.

Melon agribusiness still has good prospects in the future because the demand from consumers. The production of melon in Indonesia still needs to be improved in order to meet the demand of consumers. Efforts that can be done is increase production and quality of melon. The quality of melon produced is dependent on the quality of the seeds. The role of seed on horticultural agribusiness can not be replaced. So far, the seed

requirement for agribusiness development is fulfilled from domestic and imported production. Seed imports are conducted because the production of domestic seeds is not sufficient to meet the needs and limitations of the availability of varieties of quality seeds.

To increase the production of melon seeds, special effort is required in the cultivation technique. The most important techniques in the production of melon seeds are pollination techniques. The maturity period of stigma and pollen in flowering plants occurs in a short time between 1-3 days. Some types of plants, stigma maturity period and pollen only occurs within a few hours (Heslop-Harrison and Heslop-Harrison, 1970). In the production of melon seeds, the success of pollination is influenced by the maturity of the male and female flowers themselves. It therefore takes a suitable time of pollination to see the receptivity of stigma and pollen viability at the same level. Effective timing of pollination will minimize failure in the production of melon seeds, especially during pollination. The second factor that inhibit the production of melon seeds is the number of male flowers per plant less than the female flowers and the complete flower. Number of male anf female flower was sensitive to environment (Ahmed, 2004). Therefore the proportion of the number of male flowers to the female flowers used in the pollination process is also very important to determine the effective pollination to produce a good number of seeds

MATERIALS AND METHODS

This experiment was conducted on experimental field of Faculty of Agriculture, Brawijaya University, in Jatimulyo, Lowokwaru, Malang with altitude of 700 meters (above sea level) with daily average temperature 18^{o}-27^{o}C and humidity 79-86%. This study was conducted from February until May 2017. The tools used in this research were cutter, tweezers, plastic tray, towel, slider, roll meter, scales, sprayer, scissors, and name plaque. The materials used in this study consisted of seedling Melindo 15 varieties released by PT BISI International Tbk. The materials used in the process of cultivation were silver black plastic mulch, bamboo pedicure, NPK fertilizer, compost fertilizer, insecticide, fungicide, clip, newspaper, and yarn.

The plants was randomly arranged. The first factor was the effect of pollination time. The treatment were: (W1) at 06.00-07.00 a.m., (W2) at 08.00-09.00 a.m., (W3) at 10.00-11.00 a.m. The second factor was the proportion of female flowers with male flowers. The treatments were: (P1) 1 female flower: 1 male flower, (P2) 2 female flower: 1 male flower, (P3) 3 female flowers: 1 male flower. The observation characters were weight of fruit per plant, length of fruit, diameter of fruit, number of seed per fruit, weight of seed per plant, percentage of filled seed, weight of 100 seeds, synchronization of germination and percentage of germination. The data was analyzed by Analysis of Variance (ANOVA). The treatment and interaction that showed a significant difference tested by Honestly Significant Difference (HSD) at 5% level.

RESULTS AND DISCUSSION

Based on Table 1, treatment pollination time gave significant difference on weight of fruit per plant, length of fruit, diameter of fruit, number of seed per fruit, percentage of filled seed and synchronization of germination. Treatment proportion of female flowers with male flowers gave significant difference on weight of fruit per plant, length of fruit, diameter of fruit, number of seed per fruit, weight of 100 seeds and synchronization of germination. Interaction between pollination time and proportion of female flowers with male flowers was obtained in the character number of seed per fruit.

Weight of Fruit

Based on Table 2, treatment pollination at 06.00 – 07.00 a.m. (W1), 08.00 – 09.00 a.m. (W2) and 10.00 – 11.00 a.m. (W3) gave average weight of fruit 1099.1 g, 891.6 g and 719.1 g. Average weight per plant from all pollination time treatment showed significant difference. Weight of fruit on treatment proportion of 1 female flower with 1 male flower (P1) was 1010.8 g. While on treatment proportion 2 female flowers with 1 male flower (P2) and 3 female flowers with 1 male flower (P3) were 889.1 g and 800 g. The average weight of fruit per plant on treatment P1 showed significantly different with treatment P3, whereas in treatment P2 showed the results did not significantly different with two other treatments.

Length of Fruit

Based on Table 3, Melon due to teratment W1 (pollination time at 06.00 – 07.00 a.m.) had the longest fruit of 15.3 cm. Length of fruit melon due to treatment W2 (pollination time at 08.00 – 09.00 a.m.) and treatment W3 (pollination time at 10.00 – 11.00 a.m.) were 14.2 cm and 13.4 cm.

Table 1. Mean square of observation characters.

		Treatment	
Characters	**Pollination Time**	**Proportion of flower**	**Interaction**
Weight of fruit per plant	0.43**	0.13**	0.01^{ns}
Length of fruit	11.97**	6.74**	0.09^{ns}
Diameter of fruit	13.03**	7.54**	0.14^{ns}
Number of seed per fruit	103509.40**	65403.09**	41.69**
Weight of seed per plant	83.27*	81.54*	0.35^{ns}
Percentage of filled seed	713.89**	201.37*	2.07^{ns}
Weight of 100 seeds	0.40*	0.84**	2.34^{ns}
Synchronization of germination	228.22**	134.83**	14.56^{ns}
Percentage of germination	593.76*	131.30*	22.77^{ns}

ns=not significant; *=Significant difference; **= very significant difference

Table 2. The average weight of fruit per plant

Treatment	Weight of fuit per plant (kg)
Pollination time	
(W3) 10.00-11.00 A.M.	0.71 a
(W2) 08.00-09.00 A.M.	0.89 b
(W1) 06.00-07.00 A.M.	1.09 c
HSD 5%	0.12
Proportion of female flower and male flower	
(P3) 3 ♀ : 1 ♂	0.80 a
(P2) 2 ♀ : 1 ♂	0.88 ab
(P1) 1 ♀ : 1 ♂	1.01 b
HSD 5%	0.12

Number followed by different notations in the same column showed a significant difference with the HSD test at 5% level.

Tabel 3. The average of length of fruit

Treatment	Length of fruit (cm)
Pollination time	
(W3) 10.00-11.00 A.M.	13.4 a
(W2) 08.00-09.00 A.M.	14.2 b
(W1) 06.00-07.00 A.M.	15.3 c
HSD 5%	0.59
Proportion of female flower and male flower	
(P3) 3 ♀ : 1 ♂	13.6 a
(P2) 2 ♀ : 1 ♂	14.2 b
(P1) 1 ♀ : 1 ♂	15.1 c
HSD 5%	0.59

Number followed by different notations in the same column showed a significant difference with the HSD test at 5% level

On treatment proportion of female flower with male flower, the longest fruit was 15.1 cm which was caused by P1 (1 female flower with 1 male flower). Treatment P1 and P2 had length of fruit 14.2 cm and 13.6 cm. The fruit weight per plant on treatment P1 showed significantly different with treatment P3, whereas in treatment P2 did not significantly different with treatment P3.

Diameter of fruit

Based on table 4, pollination time treatment W1 (06.00 – 08.00 a.m.) gave the highest average diameter of fruit ie 13.4 cm whereas W2 and W3 were 12.2 cm and 11.3 cm. The P1 treatment gave the highest diameter of 13.2 cm, while P2 gave average fruit diameter of 12.2 cm. The smallest diameter was obtained on P3 with the average fruit diameter of 11.62 cm.

Number of seed per fruit

According to Table 5, the combination of treatments showed the highest average number of seeds observed was the combination of W1P1 and W1P2. In the treatment of pollination time W1 showed the highest number of seeds compared with the treatment of pollination time W2 and W3

while the treatment flower proportion of P1 and P2 showed the higher average number of seeds per fruit than the treatment of P3.

Weight of Seed per fruit

The pollination time treatment on W1 gave the highest average weight of seed 16.0 g while on W2 and W3 pollination gave average weight of seed 12.5 g and 10.9 g. The proportion female and male flowers P1 gave the highest average weight of seed 15.9 g, while P2 and P3 gave average weight of seeds 12.7 g and 10.8 g (Table 6).

Percentage of Filled Seed

Pollination time treatment W1 gave highest average percentage of filled seed 98.47%, while on W2 and W3 were 93.37% and 83.3%. In the proportion of female flower with male flower, the highest average percentage of filled seed was derived in P1 (95.88%), while in P2 and P3 were 91.5% and 87.69% (Table 7).

Weight of 100 Seeds

The highest weight of 100 seeds was obtained at treatment pollination time W1 (2.6 g). Whereas at W2 and W3 were 2.3 g and 2.5 g. On treatment porportion of female flowers with male flower, the highest weight of 100 seeds was obtained on P1 (2.8 g) while on P2 and P3 were 2.4 g and 2.3 g.

Synchronization of germination and percentage of germination

Based on Table 9, treatment pollination time at 06.00 – 07.00 a.m. (W1) showed an average of synchronization of germination 85.26%, while on W2 and W3 were 78.46% and 77.13%. In Treatments the proportion of female flowers with males, Treatments P1 showed the highest results compared with treatments P2 and P3. Based on Table 10, Percentage of germination on treatment W1 was the highest compared to W2 and W3. In treatments the proportion of female flowers with males, treatments P1 showed the highest percentage of germination compared to reatments P2 and P3.

The effect of pollination time on Yield and seed quality of melon

The occurrence of fertilization in melon is strongly influenced by anthesis period of melon flowers that lead to the receptivity period of stigma. Stigma receive pollen for a short time, therefore pollination timing is an important factor that determining the quality of fruits and seeds (Herrero, 2003). The proportion of female flower and male flower is also related to the amount of pollen given to the pistil. According to Björkman (1995), the amount of pollen pollinated into stigma is very influential on the success of fertilization. Based on the results of research conducted, Pollination Time showed significantly different results on fruit weight, fruit length, fruit diameter, seed weight per plant, number seed per plant, filled seed, weight of 100 seeds, synchronization of germination, and Percentage of germination. Pollen with high viability will first fertilize an egg cell, and produce good quality fruits and high-viability seeds when the flowers are in optimum state (Widiastuti, 2008).

Early pollination cause longer period of process of seeds filling so as to allow seeds to store more photosyntat into the seeds. In this study, the results showed the highest weight of seed obtained at pollination at 06.00-07.00 a.m.. This is represent the time of flower anthesis also affected the period of ovul to be pollinated. In addition it must be balanced by the quality of good melon seeds. The quality of melon seeds is very influential on the quality of melon plants produced. Increasing of the dry weight of seed means increasing of dry matter distributed during the process of filling the seeds (Nurdin, 2013).

The effect of proportion of female flower and male flower on yield and seed quality of melon

The results showed that the proportion of female flower and male flower also gave significantly different results on filled seeds, weight of 100 seeds, synchronization of germination, and percentage of germination. good melon seed was supported by environmental factors and availability of food reserves in the seeds that are also very supportive in the process of seed germination (Lesilolo, Riry, and Matatula, 2013).In the cucumber, the receptive period of stigma occurred two days before and two days after the anthesis, but the formation of the seeds and the development of the fruit was more determined by ovul receptivity than stigma receptivity (Le Deunff, Sauton, and Dumas, 1993). On *zingiberaceae* showed that the success of pollination is not determined by the size and morphology of flower, but rather the ratio between pollen and ovul. Based on components of the seed quality observed can be distinguished between the good quality seeds with poor quality seeds (Wang, Zhang, and Chen, 2004).

Table 4:The Average Diameter of Fruit

Treatment	Diameter of Fruit (cm)
Pollination Time	
(W3) 10.00-11.00 A.M.	11.3 a
(W2) 08.00-09.00 A.M.	12.2 b
(W1) 06.00-07.00 A.M.	13.4 c
HSD 5%	0.53
Proportion of female flower and male flower	
(P3) 3 ♀ : 1 ♂	11.6 a
(P2) 2 ♀ : 1 ♂	12.2 b
(P1) 1 ♀ : 1 ♂	13.2 c
HSD 5%	0.53

Number followed by different notations in the same column showed a significant difference with the HSD test at 5% level.

Table 5:The Average number of seeds per fruit

Pollination Time	Proportion of female flower and male flower		
	3 ♀: 1 ♂ (P3)	2 ♀: 1 ♂ (P2)	1 ♀: 1 ♂ (P1)
(W3) 10.00-11.00 A.M.	377 a	379.7 a	439.2 bc
(W2) 08.00-09.00 A.M.	404.5 ab	521.6 d	583.5 e
(W1) 06.00-07.00 A.M.	458.9 c	644.2 f	648.4 f
HSD 5%	42.3		

Number followed by different notations in the same column showed a significant difference with the HSD test at 5% level

Table 6: The Average Weight of 100 Seeds

Treatments	Weight of Seed per Fruit (g)
Pollination Time	
(W3) 10.00-11.00 A.M.	10.9 a
(W2) 08.00-09.00 A.M.	12.5 a
(W1) 06.00-07.00 A.M.	16.0 b
HSD 5%	3.42
Proportion of female flower and male flower	
(P3) 3 ♀ : 1 ♂	10.8 a
(P2) 2 ♀ : 1 ♂	12.7 ab
(P1) 1 ♀ : 1 ♂	15.9 b
HSD 5%	3.42

Number followed by different notations in the same column showed a significant difference with the HSD test at 5% level.

Table 7: The Average Weight of 100 Seeds

Treatments	Weight of Seed per Fruit (g)
Pollination Time	
(W3) 10.00-11.00 A.M.	10.9 a
(W2) 08.00-09.00 A.M.	12.5 a
(W1) 06.00-07.00 A.M.	16.0 b
HSD 5%	3.42
Proportion of female flower and male flower	
(P3) 3 ♀ : 1 ♂	10.8 a
(P2) 2 ♀ : 1 ♂	12.7 ab
(P1) 1 ♀ : 1 ♂	15.9 b
HSD 5%	3.42

Number followed by different notations in the same column showed a significant difference with the HSD test at 5% level.

Tabel 8. The Average Weight of 100 Seeds

Treatments	Weight of Seeds (g)
Pollination Time	
(W2) 08.00-09.00 A.M.	2.3 a
(W3) 10.00-11.00 A.M.	2.5 ab
(W1) 06.00-07.00 A.M.	2.6 b
HSD 5%	0.26
Proportion of female flower and male flower	
(P3) 3 ♀ : 1 ♂	2.3 a
(P2) 2 ♀ : 1 ♂	2.4 a
(P1) 1 ♀ : 1 ♂	2.8 b
HSD 5%	0.26

Number followed by different notations in the same column showed a significant difference with the HSD test at 5% level.

Tabel 9. The Average of Synchronization of Germination (%)

Treatments	Synchronization of germination(%)
Pollination Time	
(W3) 10.00-11.00 A.M.	77.1 a
(W2) 08.00-09.00 A.M.	78.4 a
(W1) 06.00-07.00 A.M.	85.2 b
HSD 5%	2.01
Proportion of female flower and male flower	
(P3) 3 ♀ : 1 ♂	78.1 a
(P2) 2 ♀ : 1 ♂	78.5 a
(P1) 1 ♀ : 1 ♂	84.1 b
HSD 5%	2.01

Number followed by different notations in the same column showed a significant difference with the HSD test at 5% level.

Tabel 10. The Average of Percentage of Germination (%)

Treatments	Percentage of germination (%)
Pollination Time	
(W2) 08.00-09.00 A.M.	81.6 a
(W3) 10.00-11.00 A.M.	89.8 b
(W1) 06.00-07.00 A.M.	95.6 c
HSD 5%	4.53
Proportion of female flower and male flower	
(P3) 3 ♀ : 1 ♂	85.5 a
(P2) 2 ♀ : 1 ♂	89.7 ab
(P1) 1 ♀ : 1 ♂	92.0 b
HSD 5%	4.53

Number followed by different notations in the same column showed a significant difference with the HSD test at 5% level

Interaction between Pollination Time with Proportion of female flower and male flower melon

Interaction between pollination time and proportion of G06. female flowers with male flowers gave a significant difference on number of seeds per fruit. Increasing of number of melon seeds indicated increasing of pollination success. The number of seeds is related to the success of pollination and fertilization. Thus, if pollination and fertilization work well, it will produce a lot of seeds and will increase the fruit weight (Hasanuddin, 2013).

The results showed that interaction between pollination time and proportion of female flowers

and male flower gave different result on number of melon seeds. The highest number of seeds was shown by pollination conducted at 06.00-07.00 a.m. with the proportion of one female flower with a male flower. At different levels of stigma receptivity and supported by differences in the amount of pollen will result in differences number of melon seeds. This is in line with the research conducted by Wijaya, Basuki, and Purnamaningsih (2015) that the pollination time gave different responses to proportion of flower to the number of cucumber seeds. The same response was shown by the proportion between 1 male flower to 1 female flower and the proportion of 1 male flower to 2 female flowers on pollination at 06.00-07.00 a.m.

CONCLUSION

Pollination time and proportion of female to male flowers treatment are significant in several traits such as fruit weight per plant, fruit length, fruit diameter, seed weight per plant, percentage of pithy seeds, weight of 100 seeds, simultaneous germination, and germination. Indeed, for the best result of the pollination time treatment is shown at 06.00-07.00 A.M while for the proportion of female to male flowers is shown at the ratio 1:1. In addition, there is a significant interaction between pollination time and the proportion of female to male flowers that shown in the number of seeds per plant. The best combination of the treatment is identified in the combination between the pollination time at 06.00-07.00 A.M and the proportion of 1 female to 1 male flower.

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

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AUTHOR CONTRIBUTIONS

RES, ALA and MRQ conceived, designed and performed the experiments, as well as wrote the manuscript. ALA analysed the data and reviewed the manuscript. All authors read and approved the final version.

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