Asian Journal of Plant Sciences

ISSN 1682-3974

science alert

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

OPEN ACCESS Asian Journal of Plant Sciences

ISSN 1682-3974
DOI: 10.3923/ajps.2023.529.537

Research Article
Hybridization of Melon (*Cucumis melo* L.) Under Pollination Time and Flower Proportion Treatments Subjected to Two Irrigation Frequencies

[1]Alecia Bonito Leorentina, [1]Iffah Nailul Fajriyah, [1]Noer Rahmi Ardiarini, [2]Mochammad Roviq and [1]Afifuddin Latif Adiredjo

[1]Plant Breeding Laboratory, Department of Agronomy, Faculty of Agriculture, Brawijaya University, Kota Malang, Jawa Timur 65145, Indonesia
[2]Plant Physiology Laboratory, Department of Agronomy, Faculty of Agriculture, Brawijaya University, Kota Malang, Jawa Timur 65145, Indonesia

Abstract

Background and Objective: The frequency of different irrigation on melon has an impact on the success of pollination and fruit yield characteristics. The objective of this study was to determine differences in successful pollination and yield characteristics in two populations with different irrigation frequencies. **Materials and Methods:** This research was conducted by performing artificial crosses on several melon varieties. The utilized materials involved melon seeds of Melindo, Madesta and Glamour varieties. This research was carried out at the greenhouse of Brawijaya University, Malang, Indonesia. The observation was made on successful pollination and on several yield characteristics (fruit weight, fruit diameter, fruit length, flesh thickness and fruit sweetness). **Results:** The highest percentages of successful pollination occurred with proportions of 1♀:1♂, 2♀:1♂ and 3♀:1♂ with irrigation every 2 days at 06:00-11:00 am and with proportion 1♀:1♂ with irrigation every 6 days at 06:00-09:00 am. For the mean yield characteristics of melons, the largest fruit weight, fruit diameter, fruit length and flesh thickness are for the ME (Melindo) × MD (Madesta) hybrid cross. The highest average sweetness level is for the ME × ME hybrid cross. **Conclusion:** The percentage of successful pollination and melon fruit quality in normal conditions are better than under drought stress.

Key words: Drought stress, flower proportion, hybridization, melon, pollination time

Citation: Leorentina, A.B., I.N. Fajriyah, N.R. Ardiarini, M. Roviq and A.L. Adiredjo, 2023. Hybridization of melon (*Cucumis melo* L.) under pollination time and flower proportion treatments subjected to two irrigation frequencies. Asian J. Plant Sci., 22: 529-537.

Corresponding Author: Afifuddin Latif Adiredjo, Plant Breeding Laboratory, Department of Agronomy, Faculty of Agriculture, Brawijaya University, Kota Malang, Jawa Timur 65145, Indonesia

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 an annual plant and is a promising prospect for farmers. It is one of the most important commercial crops in the world. The origin of the melon cannot be known with certainty, but a recent study suggests that melons originate from Asia[1]. Melon has very good compounds to improve health[2]. It contains important vitamins and minerals. In addition, melon has an excellent source of phytonutrients for health, although consumer preferences are dominated by the sweetness, aroma and texture of fruit[3]. The yield and fruit quality of melons have wide variability for traits such as morphology, sweetness and climatic adaptation[4].

Melon production in Indonesia fluctuates, it is caused by melon being a subtropical plant and limited use of superior seeds. The demand for melons is increasing due to being a sweet fruit with a fresh taste as well as a crispy texture. Therefore, the supply of melons needs to be made constantly available. The structure of the melon flower consists of both male staminate and hermaphrodite flowers or also called andromonoecious, so melon plants require artificial hybridization to increase fruit quality and quantity[5]. The availability of melons is related to the availability of seeds. Efforts to reduce dependence on melon seed imports are carried out through artificial pollination. However, the success of melon pollination is still low. This is caused by improper hybridization techniques. Hybridization has contributed to increasing the quantity and/or quality of most crop production worldwide[6]. The application of the artificial hybridization method with the treatment of pollination time at 06:00-07:00 am and a proportion of female flowers and male flowers of 1♀:1♂ can minimize pollination failure[7]. The research had been carried out by involving conditions of irrigation field capacity. However, the best hybridization method is not known when melon plants are under drought-stress conditions. The difference also depends on plant development response to successful pollination. The purpose of this research was to determine differences in successful pollination and to determine differences in yield characteristics on several sets of hybrid crosses of melon plants in two populations with different irrigation frequencies.

MATERIALS AND METHODS

This research was conducted from January to February, 2023. It was conducted at the Greenhouse of the Faculty of Agriculture, Brawijaya University, Jatimulyo Hamlet, Lowokwaru Sub-District, Malang, East Java, Indonesia. The research location is at an altitude of 525 m above sea level with an average daily temperature of 18-27°C.

The planting materials used in this study were Melindo (ME) and Madesta (MD) from Indonesia, while Glamour (GL) from Japan. The total number of seeds of ME as the female parent was 162 seeds, while ME, MD and GL as the male parents, respectively 36 seeds. The materials used in this study were rope, polybags, organic manure, nitrogen, phosphate, potassium fertilizer, KNO_3 fertilizer, masking paper, yarn, cotton, 70% alcohol and labels. The tools used were tweezers, a sprayer, a ruler, a digital scale (Radwag made in Poland), a Brix refractometer (Atago made in Japan), a caliper and a camera (Fujifilm XC15-45 mm F3.5-5.6 OIS PZ).

Research methods: This research used a method based on the research conducted by Respatijarti *et al.*[7]. The execution of the previous research involved crosses of three melon varieties and ME selfing as a control. The hybrid crosses were (i) Melindo (ME) as the female parent with Madesta (MD) as the male parent, (ii) Melindo (ME) as the female parent with Glamour (GL) as the male parent and (iii) Melindo (ME) as the female parent with Melindo (ME) as the male parent. Each hybrid cross was put under the two treatment factors of time of pollination (W) and proportion between female flowers and male flowers (P). Three different pollination times were used, which were W1 = 06:00-07:00 am, W2 = 08:00-09:00 am and W3 = 10:00-11:00 am. Three different proportions of female flowers and male flowers were used: P1 = 1♀:1♂, P2 = 2♀:1♂ and P3 = 3♀:1♂. Thus, there were nine treatment units (W1P1, W1P2, W1P3, W2P1, W2P2, W2P3, W3P1, W3P2 and W3P3) for each hybrid cross.

The modification in this research was that each set for the hybrid crosses consisted of 27 plants as female parents and six male parent plants and 27 plants were used in the selfing set. One flower was pollinated on each plant. This research is divided into two populations based on different irrigation frequencies. The first population is normal conditions (condition N) which is every 2 days of irrigation. The second is under drought stress (condition D) which is every 6 days of irrigation. The observation was made on successful pollination and on several yield characteristics (fruit weight, fruit diameter, fruit length, flesh thickness and fruit sweetness) using the single plant method.

Statistical analysis: The normality of the research data was estimated using the Shapiro-Wilk test, while the homogeneity of the data was estimated using Levine's Test. The observational data on successful pollination was analyzed using the Mann-Whitney U test (U-test) at a significance level of 5%, while the resulting characteristics were analyzed using an unpaired t-test at a significance level of 5%. All data analysis used SPSS 16 software.

RESULTS

Successful pollination: It could be observed 3-5 days after pollination of female flowers. Flowers that have been successfully pollinated are indicated by ovaries showing a green color being sturdy and increasing in size. Conversely, failed pollination is indicated by the ovary turning yellow and falling off easily. The percentage of successful pollination under normal conditions was approximately 58.33 to 100% (Table 1). The highest percentage of success was found for the treatment unit of 06:00-11:00 am irrigation time with the examined proportions of 1♀:1♂, 2♀:1♂ and 3♀:1♂. Meanwhile, the percentage of successful pollination under drought stress was approximately 25 to 75% (Table 2).

The results of the U-test showed that the average successful pollination rates in normal conditions were not significantly different for all sets. However, the mean percentage was significantly different between the crosses ME×ME and ME×GL in drought stress (Table 3). The results of the U-test of successful pollination rates of ME selfing and hybrid crosses between normal conditions and drought stress were significantly different for all sets (Table 4). The results of the U-test on several sets of hybrid crosses under normal conditions compared to drought stress showed significantly different results for the ME selfing and ME×ME sets and very significantly different results for the ME×MD and ME×GL sets.

Yield characteristics: In the research that had been carried out, the results of fruit weight (Table 5), fruit diameter (Table 6), fruit length (Table 7) and thickness of fruit flesh (Table 8) for the ME×MD hybrid crosses in normal conditions and drought stress showed higher mean values than for other hybrid crosses. The ME×ME hybrid crosses under normal conditions showed the highest average fruit sweetness level compared to the other hybrid crosses (Table 9). The highest mean for all yield characteristics was at W1P2.

The result of the t-test on the yield characteristics of melon in normal conditions and drought stress were presented in Table 10. The results of the t-test of fruit weight were significantly different in normal conditions at ME×ME and ME selfing and ME×MD and ME selfing and then in drought stress at ME×ME and ME selfing, ME×MD and ME selfing and ME×MD and ME×GL. The results of the t-test of fruit diameter were significantly different in normal conditions

Table 1: Percentages of successful pollination under normal conditions

	ME selfing (%)			ME×ME (%)			ME×MD (%)			ME×GL (%)			
Treatment	1	2	3	1	2	3	1	2	3	1	2	3	Mean (%)
W1P1	100	100	100	100	100	100	100	100	100	100	100	100	100
W1P2	100	100	100	100	100	100	100	100	100	100	100	100	100
W1P3	100	100	100	100	100	100	100	100	100	100	0	100	91.67
W2P1	100	0	100	100	0	100	100	100	100	100	0	100	75
W2P2	0	100	100	100	0	100	100	100	100	100	100	100	83.33
W2P3	100	100	100	100	100	100	100	100	100	100	100	100	100
W3P1	0	100	0	100	100	0	100	100	100	0	100	0	58.33
W3P2	100	100	100	100	100	100	100	100	100	100	100	100	100
W3P3	100	100	100	100	100	100	100	100	100	100	100	100	100

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, P1: Female and male flowers proportion at 1♀:1♂, P2: Female and male flowers proportion at 2♀:1♂ and P3: Female and male flowers proportion at 3♀:1♂

Table 2: Percentages of successful pollination under drought stress

	ME selfing (%)			ME×ME (%)			ME×MD (%)			ME×GL (%)			
Treatment	1	2	3	1	2	3	1	2	3	1	2	3	Mean (%)
W1P1	0	0	0	100	100	100	100	100	100	100	100	100	75
W1P2	0	100	0	0	100	100	0	100	100	0	0	0	41.67
W1P3	0	100	100	0	100	100	0	0	0	0	100	0	41.67
W2P1	100	100	100	100	100	100	100	0	100	0	100	0	75
W2P2	0	0	0	100	0	0	0	100	0	100	0	0	25
W2P3	0	100	0	100	0	100	0	100	0	0	0	0	33.33
W3P1	0	100	100	0	100	0	0	0	0	0	100	0	33.33
W3P2	0	100	100	0	0	100	0	0	100	0	0	0	33.33
W3P3	0	0	0	0	100	0	0	100	0	0	100	0	25

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, 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 3: U-test of successful pollination in normal conditions and drought stress

	U-test probability	
Set	Normal condition	Drought stress
ME×ME and ME selfing	0.873^{ns}	0.269^{ns}
ME×MD and ME selfing	0.066^{ns}	1.000^{ns}
ME×GL and ME selfing	1.000^{ns}	0.485^{ns}
ME×ME and ME×MD	0.065^{ns}	0.206^{ns}
ME×ME and ME×GL	0.873^{ns}	0.033*
ME×MD and ME×GL	0.066^{ns}	0.390^{ns}

ME: Melindo variety, MD: Madesta variety, GL: Glamour variety, ns: Not significantly different and *Significantly different at 0.05

Table 4: U-test of successful pollination rates of ME selfing and hybrid crosses between normal conditions and drought stress

Set	U-test probability
ME selfing (N) and ME selfing (D)	0.011*
ME×ME (N) and ME×ME (D)	0.023*
ME×MD (N) and ME×MD (D)	0.000**
ME×GL (N) and ME×GL (D)	0.003**

ME: Melindo variety, MD: Madesta variety, GL: Glamour variety, N: normal conditions, D: drought stress, *Significantly different at 0.05 and **Very significantly different at 0.01

Table 5: Mean of fruit weight in normal conditions and drought stress

	Fruit weight (g)								
Treatment	ME selfing (N)	ME×ME (N)	ME×MD (N)	ME×GL (N)	ME selfing (D)	ME×ME (D)	ME×MD (D)	ME×GL (D)	Mean (g)
W1P1	913	1481.67	1639.33	870.67	-	1162	1625	670	1194.524
W1P2	1068.7	1420	1353.67	1459.33	1478	850	1642.5	-	1324.6
W1P3	797.3	1201.67	767.67	530.5	1401.5	982.5	-	965	949.4486
W2P1	460.5	1241.5	1662	326	958.67	732.33	1678	819	984.75
W2P2	831	969.5	905.67	678	-	778	1762	452	910.8814
W2P3	931.3	864	841	992.67	1043	1006	926	-	943.4243
W3P1	705	1049	1243.67	357	1127.5	1194	-	838	930.5957
W3P2	865	1009	802	1023	611.5	827	651	-	826.9286
W3P3	817	1052.67	1400.67	1387	-	839	1398	699	1084.763
Mean	820.98	1143.22	1179.52	847.13	1103.36	930.09	1383.21	740.5	

-: No fruit formed, 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♂, N: Normal conditions and D: Drought stress

Table 6: Mean of fruit diameter in normal conditions and drought stress

	Fruit diameter (cm)								
Treatment	ME selfing (N)	ME×ME (N)	ME×MD (N)	ME×GL (N)	ME selfing (D)	ME×ME (D)	ME×MD (D)	ME×GL (D)	Mean (cm)
W1P1	12.35	13.68	15.12	11.23	-	13.75	14.36	11.17	13.09
W1P2	12.98	14.37	14.06	14.19	14.54	12.31	14.84	-	13.90
W1P3	10.8	13.57	11.47	9.94	14.54	12.18	-	12.55	12.15
W2P1	10.12	13.5	15.5	7.94	12.19	11.16	14.85	11.33	12.07
W2P2	12.41	12.09	12.24	10.73	-	11.61	14.85	9.1	11.86
W2P3	12.49	12.21	11.82	12.34	13.9	11.9	12.1	-	12.39
W3P1	11.3	13.12	13.17	8.53	13.07	13.53	-	10.9	11.95
W3P2	11.89	12.64	11.7	12.89	10.26	12.49	11.24	-	11.87
W3P3	12	12.78	13.97	14.03	-	12.19	14.13	11.42	12.93
Mean	11.81	13.11	13.23	11.31	13.08	12.35	13.77	11.08	

-: No fruit formed, 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♂, N: Normal conditions and D: Drought stress

at ME×ME and ME selfing, ME×MD and ME selfing, ME×MD and ME×GL and then in drought stress at ME×GL and ME selfing, ME×ME and ME×MD, ME×ME and ME×GL and ME×MD and ME×GL. The results of the t-test of fruit length were significantly different in normal conditions at ME×ME and ME selfing and then in drought stress at ME×ME and ME×MD and ME×MD and ME×GL. The results of the t-test of flesh thickness were significantly different in normal conditions at ME×ME and ME selfing and ME×MD and ME selfing and then in drought stress at ME×ME and ME×MD and ME×MD and ME×GL. The results of the t-test of fruit sweetness were significantly different in normal conditions at

Table 7: Mean of fruit length in normal conditions and drought stress

	Fruit length (cm)								
Treatment	ME selfing (N)	ME×ME (N)	ME×MD (N)	ME×GL (N)	ME selfing (D)	ME×ME (D)	ME×MD (D)	ME×GL (D)	Mean (cm)
W1P1	11.37	13.11	14.11	11.28	-	12.35	15.73	11.5	12.78
W1P2	12.4	13.43	13.11	13.89	14.4	11.6	14.5	-	13.33
W1P3	11.98	13.02	10.8	10.3	13.95	11.95	-	13.3	12.19
W2P1	9.35	13.1	14	8.35	12.13	11.4	15.55	11.9	11.97
W2P2	11.25	11.6	11.67	10.76	-	11.7	16.5	9.3	11.83
W2P3	12.63	11.18	11.49	12.37	10.9	13.45	12.5	-	12.07
W3P1	10.5	12.1	12.07	9.7	12.95	13.1	-	12.1	11.79
W3P2	11.52	11.73	10.77	12.31	10.45	11.7	9.7	-	11.17
W3P3	10.77	11.9	13.13	13.22	-	9.9	13.7	11.3	11.99
Mean	11.31	12.35	12.35	11.35	12.46	11.91	14.03	11.57	

-: No fruit formed, 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♂, N: Normal conditions and D: Drought stress

Table 8: Mean of flesh thickness in normal conditions and drought stress

	Flesh thickness (mm)								
Treatment	ME selfing (N)	ME×ME (N)	ME×MD (N)	ME×GL (N)	ME selfing (D)	ME×ME (D)	ME×MD (D)	ME×GL (D)	Mean (mm)
W1P1	30.03	35.18	43.2	33.82	-	34.9	41.6	28.2	35.28
W1P2	32.23	38.15	37.82	37.97	39.5	31.2	43.2	-	37.15
W1P3	24.8	33.42	27.85	25.65	37.35	33.05	-	24.15	29.47
W2P1	22.88	31.8	36.5	19.8	32.7	29.67	40.25	35.9	31.19
W2P2	30.2	30.75	30.7	28.87	-	28.3	42.5	19.5	30.12
W2P3	31.02	27.7	27.53	31.2	35	31.2	35.8	-	31.35
W3P1	28.6	34.35	34.27	21.1	33	36.7	-	33.8	31.69
W3P2	26.5	31	25.4	31.23	25.8	29.22	26.1	-	27.89
W3P3	29.52	29.28	36.57	36.05	-	31.7	37.1	32.1	33.19
Mean	28.42	32.4	33.31	29.52	33.89	31.77	38.08	28.94	

-: No fruit formed, 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♂, N: Normal conditions and D: Drought stress

Table 9: Mean of fruit sweetness in normal conditions and drought stress

	Fruit sweetness (^{0}Brix)								
Treatment	ME selfing (N)	ME×ME (N)	ME×MD (N)	ME×GL (N)	ME selfing (D)	ME×ME (D)	ME×MD (D)	ME×GL (D)	Mean (^{0}Brix)
W1P1	8.33	8.33	10.33	5.6	-	8	5.67	4	7.18
W1P2	6.47	11.8	7.73	8.87	7	5.3	6.9	-	7.72
W1P3	4.4	9.4	6.67	7.6	6.5	5.6	-	8	6.88
W2P1	6.4	9.8	9	4.4	6.8	5	5.5	6.4	6.66
W2P2	9.6	5.6	8.93	7	-	7	4	4.8	6.70
W2P3	6.67	7.2	8.07	7.47	8.4	6	4	-	6.83
W3P1	9	9.8	8	4.4	4.3	10.6	-	5	7.30
W3P2	7.27	8.4	7.47	8.07	5.1	7	4	-	6.76
W3P3	7.87	9.6	9.93	7.87	-	7	5.2	6	7.64
Mean	7.33	8.88	8.46	6.81	6.35	6.83	5.04	5.7	

-: No fruit formed, 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♂, N: Normal conditions and D: Drought stress

ME×ME and ME×GL and ME×MD and ME×GL and then in drought stress at ME×ME and ME×MD.

The t-test on several yield characteristics between normal conditions and drought stress on the ME selfing and ME×MD sets showed negative values (Table 11). Based on this, it is known that the mean yield characteristics (fruit weight, fruit diameter, fruit length and fruit flesh thickness) in drought stress are greater than in normal conditions. Meanwhile, the results of the t-test between normal conditions and drought stress for the ME×ME and ME×GL hybrid crosses showed positive values. Based on this, it is known that the mean yield characteristics (fruit weight, fruit diameter, fruit length and fruit flesh thickness) in normal conditions are greater than in drought stress.

Table 10: T-test of yield characteristics in normal conditions and drought stress

Set	Fruit weight	Fruit diameter	Fruit length	Flesh thickness	Fruit sweetness
ME×ME and ME selfing (N)	3.604**	3.286**	2.407*	2.687*	1.957^{ns}
ME×MD and ME selfing (N)	2.713*	2.395*	1.911^{ns}	2.226*	1.711^{ns}
ME×GL and ME selfing (N)	0.176^{ns}	-0.62^{ns}	0.067^{ns}	0.470^{ns}	-0.690^{ns}
ME×ME and ME×MD (N)	-0.260^{ns}	-0.215^{ns}	0.004^{ns}	-0.411^{ns}	0.594^{ns}
ME×ME and ME×GL (N)	1.923^{ns}	2.268*	1.537^{ns}	1.220^{ns}	2.585*
ME×MD and ME×GL (N)	1.825^{ns}	2.116^{ns}	1.367^{ns}	1.324^{ns}	2.460*
ME×ME and ME selfing (D)	-1.401^{ns}	-1.148^{ns}	-0.827^{ns}	-1.107^{ns}	0.566^{ns}
ME×MD and ME selfing (D)	1.320^{ns}	0.787^{ns}	1.380^{ns}	1.385^{ns}	-1.845^{ns}
ME×GL and ME selfing (D)	-2.461*	-2.457*	-1.061^{ns}	-1.547^{ns}	-0.783^{ns}
ME×ME and ME×MD (D)	-2.648*	-2.436*	-2.453*	-2.840*	2.397*
ME×ME and ME×GL (D)	2.117^{ns}	2.516*	0.561^{ns}	1.046^{ns}	1.337^{ns}
ME×MD and ME×GL (D)	3.417**	3.635**	2.280*	2.699*	-0.945^{ns}

ME: Melindo variety, MD: Madesta variety, GL: Glamour variety, N: Normal conditions, D: Drought stress, ns: Not significantly different, *Significantly different at 0.05 and **Very significantly different at 0.01

Table 11: T-test of yield characteristics for hybrid crosses between normal conditions and drought stress

Set	Fruit weight	Fruit diameter	Fruit length	Flesh thickness	Fruit sweetness
ME selfing (N) and ME selfing (D)	-2.270*	-1.923^{ns}	-1.724^{ns}	-2.729*	1.220^{ns}
ME×ME (N) and ME×ME (D)	2.402*	2.034^{ns}	1.020^{ns}	0.450^{ns}	2.490*
ME×MD (N) and ME×MD (D)	-1.036^{ns}	-0.713^{ns}	-1.836^{ns}	-1.606^{ns}	5.89**
ME×GL (N) and ME×GL (D)	0.593^{ns}	0.235^{ns}	-0.251^{ns}	0.175^{ns}	1.358^{ns}

ME: Melindo variety, MD: Madesta variety, GL: Glamour variety, N: normal conditions, D: drought stress, ns: not significantly different, *Significantly different at 0.05 and **Very significantly different at 0.01

DISCUSSION

The highest success rate of hybridization under normal conditions occurred at 06.00-11.00 am, while under drought stress conditions at 06.00-09.00 am. It's because the temperature in the planting area is low with high humidity. Pollination was performed in the morning. The highest pollen viability is when the flowers bloom, after which the viability decreases throughout the day[8]. An increase in air temperature at approximately noon can reduce pollen viability and stigma receptivity due to the drying of pollen and stigma[9]. Environmental conditions also affect the success of pollination. Drought stress can inhibit the formation of the pollen tube to the ovule, thereby reducing the efficiency of successful fertilization[10].

The proportion between female flowers and male flowers is related to the amount of pollen received by the pistil. Under normal conditions, the amount of pollen is thought to be sufficient to pollinate the pistil because it is supported by viable pollen and receptive stigma. However, under drought stress, more pollen is needed to increase the chance of successful pollination. The success of fruit formation is determined by the amount of pollen that is sufficient to pollinate the pistil[11]. The average pollen production of melons is approximately 11,176 pollen grains per flower and can be influenced by environmental conditions, meanwhile, melon plants can lose more than 57% of pollen during the first 2 hrs after anthesis[12]. Drought stress can reduce pollen availability and increase the potential for sterile pollen[13]. Thus, drought stress is thought to affect melon plants by reducing the quantity and quality of pollen received by the pistil.

The success of pollination under normal conditions showed a high percentage and the results of the U-test were not significantly different in comparing ME selfing and the hybrid crosses. The highest percentage of successful pollination was found for the treatment unit of 06:00-09:00 am irrigation time and the examined proportion of 1♀:1♂. Pollination success is an indicator in determining the compatibility between the male and female parents[14]. Thus, it can be assumed that the male parents of the Melindo, Madesta and Glamour varieties are compatible with the female parents of the Melindo variety.

The yield characteristics of melons were observed when the fruits had reached the physiological maturity stage, ideal harvesting was conducted 30-35 days after pollination. Melon fruit has a variety of average yield characteristics and this can be caused by environmental factors and care during the fruit formation period[15].

Melon fruit weight is one of the important phenotypic characteristics to measure plant productivity[16]. Fruit diameter, fruit length and flesh thickness have a positive and very significant correlation with fruit weight on melon plants[17]. If the melon fruit has a high average weight, it can be assumed that the fruit has a high average fruit diameter, fruit length and flesh thickness.

Respatijarti *et al.*[7] reported that there were significant differences, based on the results of the t-test analysis, on the results of the characteristics of the ME×MD hybrid cross in comparison to ME selfing and the other hybrid crosses. The use of the Madesta variety as a male parent is known to increase the average weight of melon fruit. Based on this, it can be assumed that the use of male parents of the Madesta variety had a dominant effect on female parents of the Melindo variety on the characteristics of fruit weight, fruit diameter, fruit length and thickness of fruit flesh, which requires further research. The use of male parents on cucurbit plants had a significant effect on the weight, diameter and fruit length characteristics that resulted from the cross[18]. Thus, the ME×MD hybrid cross has the potential in plant breeding programs to increase the fruit weight characteristic of melon plants.

Melon fruit quality in normal conditions was better than in drought stress. Meanwhile, the average fruit weight in normal conditions (326-1,662 g) was less than in drought stress (452-1,762 g), which is indicated by the t-test results that are significantly different and not significantly different with positive or negative values.

The accumulation of soluble solids in melons is an interaction between genotype expression and environmental factors[12]. In addition, the fruit sweetness level has a significant effect on the interaction of maturity stages and planting seasons[19]. The quality of melon strains was characterized based on quantitative data on the characteristics of fruit weight and fruit sweetness level[20]. Handayani *et al.*[21] reported that several parents of melon had a positive and highly significant general combining ability for fruit flesh thickness and total fruit soluble solid indicating that additive gene action controlled the inheritance of these traits. The average sweetness level of melons under normal conditions (4.40-11.80 ^{0}Brix) was higher than that under-drought stress (4.00-10.60 ^{0}Brix).

This result contradicted the research on melons by Ibrahim[22] in which it was stated that drought stress can decrease fruit weight, fruit length, fruit width, fruit thickness and total yield per plant, but can increase total dissolved solids in the fruit due to decreased plant water content. Irrigation that is more frequent results in higher yields but lower sweetness levels in melons[23]. One of the factors that are thought to reduce the sweetness level of the fruit but increase the fruit weight is irrigation before and during harvest[16]. In addition, the irrigation of melon plants during fruit ripening should be reduced to prevent the cracking of the fruit[24].

Reducing the volume of water given to melon plants should cause a decrease in fruit weight and yield[25]. This discrepancy is thought to be due to melon harvesting in normal conditions with the ME selfing and ME×MD sets before the physiological maturity stage. Early harvesting is carried out because some melon plants are attacked by powdery mildew and downy mildew.

Cabello *et al.*[26], reported that water deficit in melons can cause a decrease in fruit weight, thereby reducing yields by up to 22%. Ibrahim[27] reported similarly that the decrease in the mean yield characteristics of melons is possible because the physiological process of plants is slower due to drought stress. In addition to the factors already mentioned, pollination techniques can affect fruit size[28]. Furthermore, Montiel *et al.*[29] stated that inhibition of fruit formation was due to several factors, namely environmental factors and plant maintenance. During the study, it was found that insects attacked the melons, reducing fruit weight. Various other factors may also affect fruit development, such as temperature, humidity, sunlight intensity, fruit thinning time, lateral stem pruning time, fruitage when picked and fruit position on the internodes.

Failure of pollination can result from pollen and pistil drying[30], falling flowers, or pollinator efficiency. Some melon plants under drought stress were not pollinated, this was presumably due to flowers failing to develop or female flowers falling off before pollination. Treatment of water deficiency had been shown to reduce the number of flowers and pods and increase flower abortion, in *Trigonella coerulea* plants[31]. The formation of plant generative organs is highly dependent on the availability of photosynthesis, but drought stress causes reduced nutrient transport to generative organs, thereby increasing ovule damage in plants[32].

The success of pollination is not only influenced by the time of pollination and the proportion of flowers. Other factors that influence the success of pollination are the compatibility of male and female gametes with each other, optimal air temperature and humidity for pollination[26] and synchronization of flowering time between the male and female parents. If the stigma is not receptive, pollen can adhere, but the pollen tube cannot develop[33]. During the research, it was found that pests had caused damage to the flowering parts of the melon plants, causing pollination failure. The presence of pests can damage certain parts of cucurbit plants, including the leaves and flowers, which can result in yield losses reaching 30-100%[34].

In this study, differences were found between hybridization success rates in melon plants between melon populations under normal conditions and under drought stress conditions. The success rate of hybridization in populations under normal conditions has a higher success rate

than under drought stress conditions. Low temperature and high humidity levels affect the success rate of hybridization, so we recommend hybridization at 06.00-09.00 am. The limitation of this research is that pollinator skills are needed.

CONCLUSION

The growing media condition causes differences due to the success rate of hybridization. Results showed that the successful hybridization rate was better under normal watering conditions than drought-stress conditions. The success rate of hybridization under normal conditions reached 58.33-100%, while it reached 25-75% under drought-stress conditions. The highest successful hybridization rate under normal conditions occurred at 06.00-11.00 am with flower proportions of 1♀:1♂, 2♀:1♂ and 3♀:1♂ each of 100%, while on drought stress at 06.00-09.00 am with flower proportion of 1♀:1♂ with a success rate of 75%.

SIGNIFICANCE STATEMENT

The purpose of this research is to determine differences in successful pollination and to determine differences in yield characteristics on several sets of hybrid crosses of melon plants in two populations with different irrigation frequencies. The hybridization rate of melon plants was higher in the normal irrigated population than the drought stress population. Drought stress treatment causes plants to stress metabolism which causes the flowers to fall off. The follow-up science suggested by these findings is a reciprocal cross on all-set hybridization.

ACKNOWLEDGMENTS

The authors are grateful to the Directorate of Research, Technology and Community Service (DRTPM), Directorate General of Higher Education (Dirjen DIKTI) and the Institute for Research and Community Service (LPPM), Brawijaya University for providing great support in the research project.

REFERENCES

1. Sebastian, P., H. Schaefer, I.R.H. Telford and S.S. Renner, 2010. Cucumber (*Cucumis sativus*) and melon (*C. melo*) have numerous wild relatives in Asia and Australia and the sister species of melon is from Australia. Proc. Natl. Acad. Sci. USA., 107: 14269-14273.
2. Lester, G.E. and K.M. Crosby, 2002. Ascorbic acid, folic acid, and potassium content in postharvest green-flesh honeydew muskmelons: Influence of cultivar, fruit size, soil type, and year. J. Am. Soc. Hortic. Sci., 127: 843-847.
3. Lester, G., 2006. Consumer preference quality attributes of melon fruits. Acta Hortic., 712: 175-182.
4. Li, Z., L. Yao, Y. Yang and A. Li, 2006. Transgenic approach to improve quality traits of melon fruit. Sci. Hortic., 108: 268-277.
5. Tschoeke, P.H., E.E. Oliveira, M.S. Dalcin, M.C.A.C. Silveira-Tschoeke and G.R. Santos, 2015. Diversity and flower-visiting rates of bee species as potential pollinators of melon (*Cucumis melo* L.) in the Brazilian Cerrado. Sci. Hortic., 186: 207-216.
6. Ricketts, T.H., J. Regetz, I. Stephan-Dewenter, S.A. Cunningham and C. Kremen *et al*., 2008. Landscape effects on crop pollination services: Are there general patterns? Ecol. Lett., 11: 499-515.
7. Respatijarti, M. Roviq and A.L. Adiredjo, 2019. Pollination time and proportion of female to male flowers affecting pollination effectivity and yield characters of some melon (*Cucumis melo* L.) varieties. Ann. Biol., 35: 61-66.
8. Kiill, L.H.P., E. de Araújo Feitoza, K.M.M. de Siqueira, M. de Fátima Ribeiro and E.M.S. da Silva, 2016. Evaluation of floral characteristics of melon hybrids (*Cucumis melo* L.) in pollinator attractiveness. Rev. Bras. Frutic., Vol. 38. 10.1590/0100-29452016531.
9. Cárcova, J. and M.E. Otegui, 2001. Ear temperature and pollination timing effects on maize kernel set. Crop Sci., 41: 1809-1815.
10. Hu, W., Y. Huang, H. Bai, Y. Liu, S. Wang and Z. Zhou, 2020. Influence of drought stress on pistil physiology and reproductive success of two *Gossypium hirsutum* cultivars differing in drought tolerance. Physiol. Plant., 168: 909-920.
11. Vidal, M.D.G., D.D. Jong, H.C. Wien and R.A. Morse, 2010. Pollination and fruit set in pumpkin (*Cucurbita pepo*) by honey bees. Braz. J. Bot., 33: 106-113.
12. Stanghellini, M.S., J.R. Schultheis and J.T. Ambrose, 2002. Pollen mobilization in selected cucurbitaceae and the putative effects of pollinator abundance on pollen depletion rates. J. Am. Soc. Hortic. Sci., 127: 729-736.
13. Alqudah, A.M., N.H. Samarah and R.E. Mullen, 2011. Drought Stress Effect on Crop Pollination, Seed Set, Yield and Quality. In: Alternative Farming Systems, Biotechnology, Drought Stress and Ecological Fertilisation, Lichtfouse, E. (Ed.), Springer, Dordrecht, Netherlands, ISBN: 978-94-007-0185-4, pp: 193-213.
14. Widyasmara, N.I., F. Kusmiyati and Karno, 2018. Effects of xenia and metaxenia on crossing ranti tomato and cherry tomato [In Indonesian]. J. Agro Complex, 2: 128-136.
15. Ramjan, M. and M.T. Ansari, 2018. Factors affecting of fruits, vegetables and its quality. J. Med. Plants Stud., 6: 16-18.

16. Zalapa, J.E., J.E. Staub and J.D. McCreight, 2006. Generation means analysis of plant architectural traits and fruit yield in melon. Plant Breed., 125: 482-487.
17. Chikh-Rouhou, H., I. Tlili, R. Ilahy, T. R'Him and R. Sta-Baba, 2021. Fruit quality assessment and characterization of melon genotypes. Int. J. Veg. Sci., 27: 3-19.
18. Golabadi, M., S. Ercisli and F. Ahmadi, 2019. Environmental and physiological effects on cross-ability and seed production of greenhouse cucumber. J. Seed Sci., 41: 134-143.
19. Huda, A.N., W.B. Suwarno and D.A. Maharijaya, 2018. Characteristics of melon (*Cucumis melo* L.) fruits at five maturity stages [In Indonesian]. J. Agron. Indonesia., 46: 298-305.
20. Napolitano, M., N. Terzaroli, S. Kashyap, L. Russi, E. Jones-Evans and E. Albertini, 2020. Exploring heterosis in melon (*Cucumis melo* L.). Plants, Vol. 9. 10.3390/plants9020282.
21. Handayani, D.R., S. Ashari, A.L. Adiredjo, N.R. Ardiarini and M. Roviq, 2022. Heterosis and combining ability of melon genotypes (*Cucumis melo* L.) for yield characters in full diallel crosses. Bulg. J. Agric. Sci., 28: 810-821.
22. Ibrahim, E.A., 2012. Response of some Egyptian sweet melon (*Cucumis melo* var. *Aegyptiacus* L.) cultivars to water stress conditions. J. Appl. Hortic., 14: 67-70.
23. Sensoy, S., A. Ertek, I. Gedik and C. Kucukyumuk, 2007. Irrigation frequency and amount affect yield and quality of field-grown melon (*Cucumis melo* L.). Agric. Water Manage., 88: 269-274.
24. Nwokwu, G.N., L.G. Ekwu and E.B. Utobo, 2018. Effect of water stress at different phenological stages of muskmelon (*Cucumis melo* L). Indian J. Agric. Res., 52: 452-455.
25. Faberio, C., M.F. de Santa Olalla and J.A. de Juan, 2002. Production of muskmelon (*Cucumis melo* L.) under controlled deficit irrigation in a semi-arid climate. Agric. Water Manage., 54: 93-105.
26. Cabello, M.J., M.T. Castellanos, F. Romojaro, C. Martinez-Madrid and F. Ribas, 2009. Yield and quality of melon grown under different irrigation and nitrogen rates. Agric. Water Manage., 96: 866-874.
27. Ibrahim, E.A., 2012. Variability, heritability and genetic advance in egyptian sweet melon (*Cucumis melo* var. *Aegyptiacus* L.) under water stress conditions. Int. J. Plant Breed. Genet., 6: 238-244.
28. Shin, Y.S., S.D. Park and J.H. Kim, 2007. Influence of pollination methods on fruit development and sugar contents of oriental melon (*Cucumis melo* L. cv. Sagyejeol-Ggul). Sci. Hortic., 112: 388-392.
29. Montiel, F.G., M. Serrano, D. Martinez-Romero and N. Alburquerque, 2010. Factors influencing fruit set and quality in different sweet cherry cultivars. Span. J. Agric. Res., 8: 1118-1128.
30. Widiatmoko, T., T. Agustono and M. Imania, 2012. Growth and yield of several big seed soybean genotypes by drought stress in various growth stages [In Indonesian]. Agrin, 16: 66-79.
31. Akhalkatsi, M. and R. Lösch, 2005. Water limitation effect on seed development and germination in *Trigonella coerulea* (Fabaceae). Flora-Morphol. Distrib. Funct. Ecol. Plants, 200: 493-501.
32. Barnabas, B., K. Jager and A. Feher, 2008. The effect of drought and heat stress on reproductive processes in cereals. Plant Cell Environ., 31: 11-38.
33. Sanzol, J., P. Rallo and M. Herrero, 2003. Asynchronous development of stigmatic receptivity in the pear (*Pyrus communis*; Rosaceae) flower. Am. J. Bot., 90: 78-84.
34. Khan, M.M.H., M.Z. Alam, M.M. Rahman, M.I.H. Miah and M.M. Hossain, 2012. Influence of weather factors on the incidence and distribution of pumpkin beetle infesting cucurbits. Bangladesh J. Agric. Res., 37: 361-367.