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Heritability, Heterosis and Correlations of Fruit Characters and Yield in Thai Slicing Melon (*Cucumis melo* L. var. conomon Makino)

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ABSTRACT

Two inbred lines (RM1 and LM2) of slicing melon (*C. melo* L. var. *conomon* markino) and their related progenies were determined for their quantitative inheritance and heterosis of fruit width, length, shape index, weight, fruit number per plant and yield and correlations among these traits. The results indicated that heritability based on fruit width, fruit length, fruit shape index, and fruit weight were relatively high at 0.60, 0.68, 0.55, and 0.71 respectively. The heritability as considered from fruit number per plant and yield were also high at 0.60 and 0.61. Heterobeltiosis was recorded to be 12.71% for fruit number per plant while total yield per plant showed 8.20% heterosis. The performance of fruit characters of F_1 hybrid was not exceeding over that of the better parent or equal to the mid-parent values. The width of marketable immature fruit showed negative correlation to fruit length and fruit shape. Fruit shape and size were not related to fruit number per plant and yield while fruit number per plant had highly positive correlation to yield per plant.

Key words: Thai slicing melon, heritability, heterosis, correlation

INTRODUCTION

Thai slicing melon (*Cucumis melo* L. var. conomon makino) is simply called as melon cucumber. The vernacular name in Thailand is Taeng-Thai (Paje and Vossen, 1993). Thai people use immature fruit of slicing melon for consumption in the same way as cucumber.

Cultivating areas of this melon in Thailand have not been formally reported. However, this fruit vegetable can be commonly found in wholesale markets and local markets especially in central regions. In the future, it is expected to become popular for consumption because the flesh is crispier than cucumber. For cultivation, it has good advantages on short crop duration, tolerance to disease and well-adapted to various conditions (Tindall, 1983).

Since slicing melon is classified as a cross-pollinated crop, genetic and fruit character variability could be high among its population such as fruit shape, fruit skin color, and fresh color. This is due to freely cross pollinating between cultivars, so there are many intermediate types (George, 1999).

Although Thai slicing melon has an advantage in plant growth characters, it gives low yield and unattractive fruit characters resulting to lower price when compared to cucumber. The F_1-hybrid variety should solve these problems. This study was conducted to find the inheritance and correlation of fruit characters and yields that might be helpful in the breeding programs for improving marketable yield and fruit shape.

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MATERIALS AND METHODS

Inbred lines selection

Two inbred lines of round (RM1 as P_1) and cylindrical (LM2 as P_2) fruit types were crossed to make an F_1 hybrid (without reciprocal) and were followed by related progenies as F_2 and back-crossed to both parents. Forty plants of P_1, P_2, F_1, F_2, BCP_1 and BCP_2 were grown in upper trailing system. Individual plant in each population was observed separately for all characters. The fruit characters were observed on immature fruits. Female flowers were marked with colored wire at blooming date and measured 7 days after anthesis. All the observations were recorded as a mean of three fruits of each plant on immature fruit length, width, shape index (L/W ratio) and weight.

Fruit collection and characterization

The yield and fruit numbers per plant were recorded on individual plant of all populations. To assure that the immature fruits were harvested at the same stage, the female flowers were marked with colored wire at blooming date with the certain color designated for that day. The immature fruits were harvested at the stage of seven days after anthesis. Fruit harvesting was done daily for 20 days. The data of immature fruit weight per plant and fruit number per plant were recorded.

To verify correlations of immature fruit width, length, shape and yield, the data of 40 plants of the F_2 population which assumed complete segregation of various fruit types were designed to analyze correlation values between fruit width, length, shape index, weight, fruit number per plant and marketable yield per plant.

Data analysis

The Microsoft Excel program was employed for the analysis of variance and correlation for all traits recorded.

Narrow-sense heritability of fruit characters, yield and fruit number per plant was analyzed by Warner's method (Warner, 1952).

$$\text{Heritability } (h^2) = \frac{(1/2)D}{V_{F_2}}$$

(1/2) D = the additive genetic component of variance of F_2

and V_{F_2} = total within variance of F_2

and $(1/2)\,D = 2(V_{F_2}) - (V_{B_1} + V_{B_2})$

Where V_{B_1} and V_{B_2} are the total within variance of the backcrosses of the F_1 to the respective parents.

Heterosis and heterobeltiosis (better parent heterosis) were calculated using the following formulae.

Heterosis $= ((F_1 - MP)/MP) \times 100$

Heterobeltiosis $= ((F_1 - HP)/HP) \times 100$

Where MP = mid-parent mean and

HP = better-parent mean.

Favorable heterosis was assigned if F_1 mean was significantly different from its mid-parent mean and favorable heterobeltiosis was given if F_1 mean was significantly different from its better-parent mean.

RESULTS AND DISCUSSION

Heritability of fruit characters and yields

Narrow sense heritability (h^2) of six characters was estimated from the data of populations derived from crossing between two lines P_1 (RM1) and P_2 (LM2). Generation means and heritability are presented in Table 1.

Fruit size Heritability based on fruit width and length were as high as 0.60 and 0.68 respectively. It signified the possibility of improving these characters as desired. The genetic gain of conducting mass selection at ten percent for these characters was estimated at 0.46 for width and 2.83 for fruit length.

Fruit shape The shape index was

measured to define fruit shape in terms of quantitative character. It was obvious from the generation mean comparison that P_1 and P_2 had the lowest and the highest index values of 1.2 and 4.20, respectively. The narrow sense heritability determined for this character was as high as 0.55. The genetic gain of conducting mass selection at ten percent for this character was estimated at 0.71.

Fruit weight The marketable fruit of cylindrical shape in P_2 parent made the highest fruit weight of 102.03 g. While the fruit of round shape in P_1 parent produced lower fruit weight at 70.13 g and it was not statistically different from its F_1, F_2, and BC_1. The narrow sense heritability determined for fruit weight was as high as 0.71. The genetic gain of conducting mass selection at ten percent for this character was estimated at 16.74 (Table 1).

Fruit number per plant F_1 generation had the best performance considered from fruit number per plant, followed by that of BC_2, whereas the poorest performance was P_1. The narrow sense heritability examined for this character was as high as 0.60. The genetic gain when conducting mass selection at ten percent was estimated at 9.06 fruit per plant.

Yield per plant P_2 parent gave the best performance for yield per plant (2.62 kg), followed by that of first filial (2.19 kg), whereas the P_1 parent yield was the lowest (1.42 kg).The narrow sense heritability evaluated for this character was as high as 0.61. Thus the genetic gain of conducting mass selection at ten percents was estimated at 0.75 (Table 1).

The narrow sense heritability estimated of fruit width, fruit length, fruit shape, and fruit weight were high (55-71%). This study gave the similar results of Lippert and Hall (1982) who suggested that heritabilities of fruit diameter, fruit length, fruit shape index, and fruit weight in muskmelon were relatively high (53-71%). When, Kalb and Davis (1984) estimated moderate heritability for fruit weight and shape index in bush muskmelon (23 and 36%, respectively). Pornsuriya (2005) discovered that the cylindrical fruit shape was incompletely dominant to round fruit and this character was governed by a single gene.

Table 1 Heritability of marketable immature fruit characters and yields of slicing melon.

	Fruit characters [Z]				Yield [Z]	
	Width (cm)	Length (cm)	Shape index	Weight (g)	Fruit no. /plant.	Total yield/plant.(kg)
P_1	4.95[a]	5.04[e]	1.02[e]	70.13[c]	22.90[d]	1.42[d]
P_2	3.39[f]	14.22[a]	4.20[a]	102.03[a]	27.15[bc]	2.62[a]
F_1	4.06[d]	7.19[c]	1.78[c]	71.22[c]	30.60[a]	2.19[b]
F_2	4.35[c]	7.49[c]	1.78[c]	71.55[c]	26.18[bc]	1.89[c]
BCP1	4.56[b]	6.19[d]	1.39[d]	66.58[c]	25.28[cd]	1.71[c]
BCP2	3.80[e]	9.47[b]	2.52[b]	79.55[b]	28.48[ab]	2.16[b]
CV. (%)	7.87	18.82	22.73	14.59	24.50	26.7
F-test	**	**	**	**	**	**
h^2	0.60	0.68	0.55	0.71	0.60	0.61
ΔG	0.46	2.83	0.71	16.74	9.06	0.75

Z Means in a column followed by the same letter are not statistically different at 5% according to Duncan's new multiple range test (DMRT)

** Significant at $P < 0.01$

ΔG Genetic gain estimated for ten percent mass selection

The inheritance of fruit number per plant and yield were reported previously in muskmelon by Lippert and Hall (1982) that could be considered to be low (9-12%). This study revealed the contrast results for the characters which were estimated as high as 60 and 61%. It might be due to the fact that the studies by Lippert and Hall were observed in the mature fruit of muskmelon, whereas the immature fruit characters were determined in this study.

In general, the narrow-sense heritability of fruit characters and yield were high, indicating that the genetic variance was highly expressed in the phenotype and that superior genotype might be identified efficiently through the evaluation of phenotype. The breeding program for incorporation of these traits could be manageable and signified the high potential for improving these characters through breeding method. Pure lines can be attained by direct phenotypic selection of all traits.

Heterosis and mean performance of F_1 hybrid

The F_1 hybrid giving the mean values of fruit width, length, weight, and shape index were not exceeding over that of the better parent or equal to the mid-parent values. These might infer to the role of incomplete dominant effect or possibly epistatic gene action.

Favorable heterosis were indicated for fruit number per plant, yield per plant and, to a lesser extent, for fruit width (22.28%, 8.20% and -2.64%, respectively). The negative heterosis of fruit width, which made the fruit shape more slender and impressive for consumers, was the favorable character. Undesirable heterosis was found in fruit length, weight and fruit shape index (-25.28, -31.89, and -17.26%, respectively) (Table 2). The positive heterosis of yield per plant might be the reflection of heterobeltiosis of fruit number per plant whereas the negative heterobeltiosis was obtained from negative heterosis of fruit width, fruit length, fruit shape index, and fruit weight.

Favorable heterobeltiosis was marked on fruit number per plant as 12.71 % (Table 2). This result suggested the successive way to improve yield of F_1 hybrid through fruit number per plant. Pornsuriya (2005) also reported positive heterosis and heterobeltiosis on this trait in many crosses of slicing melon. However, the improvement of fruit shape and fruit weight, fruit length of both inbred lines should be aimed for long and cylindrical fruit in order to meet the outstanding hybrid which will give higher yield and good fruit characters.

Correlations of immature fruit sizes and marketable yield in F_2 population

The correlations among fruit characters and yield are presented in Table 3. The fruit width had highly negative correlation to fruit length and shape (r = -0.74 and -0.83, respectively). It implied that the big diameter fruit character was inherited together with short fruit and the small diameter was inherited together with cylindrical fruit trait. The result of no relationship between fruit width and fruit weight might be due to the harvesting stage of marketable fruit given 7 days after anthesis and signified little variation in fruit diameter.

The length of marketable immature fruit expressed highly positive correlation with fruit shape and fruit weight (r = 0.99 and 0.79, respectively). Increasing of fruit length gave the higher fruit shape index and fruit weight that offered positive correlation between fruit shape and weight (r = 0.70). Therefore, selection for longer fruit could be considered to improve immature fruit shape and weight.

The marketable fruit width, length, and weight of this population revealed no correlation with fruit number per plant (r = -0.06, 0.17 and 0.15, respectively). Total marketable yield per plant also had low correlation with immature fruit width, length and weight (r = -0.05, 0.29 and 0.25, respectively). It indicated that breeding

Table 2 Mean performance of F_1, mid-parents (MP) and better parent (BP), heterosis and heterobeltiosis of the studied characters.

Characters	F_1	MP	BP	Heterosis (%)	Heterobeltiosis (%)
Fruit width (cm)	4.06	4.17	4.95	-2.64 *	-18.00 **
Fruit length (cm)	7.19	9.63	14.22	-25.28 **	-49.40 **
Fruit shape index	1.78	2.61	4.20	-31.89 **	-57.70 **
Fruit weight (g)	71.22	86.08	102.03	-17.26 **	-30.19 **
Fruit No./plant	30.60	25.03	27.15	22.28 **	12.71 **
Yield/plant (kg)	2.19	2.02	2.62	8.20 *	-16.50 **

* , ** Significant at $P < 0.05$ and $P < 0.01$, respectively

Table 3 Correlation coefficients (r) of immature fruit characters and yields in F_2 populations.

Immature characters	Fruit length	Fruit weight	Shape index	Fruit no./plant [Y]	Yield (kg/plant) [Z]
Fruit width [X]	-0.74**	-0.27	-0.83**	-0.06	-0.05
Fruit length [X]		0.79**	0.99**	0.17	0.29
Fruit weight [X]			0.70**	0.15	0.25
Shape index [X]				0.22	0.26
Fruit no./plant					0.88**

[X] Immature fruit characters measured at marketable stage (7 days after anthesis)

[Y] Total marketable immature fruits from 20 harvests

[Z] Total weight of marketable immature fruits from 20 harvests

** Correlation is significant at 0.01 level

for higher fruit number and yield could be done with disregard of fruit sizes at the immature stage.

Highly positive correlation coefficients were recorded for fruit number per plant and marketable yield that gave 0.88 for correlation coefficients (Table 3). The results indicated that fruit number per plant had a close association with the yield in this population. Components of fruit number per plant should be considered for yield improvement in Thai slicing melon breeding programs.

CONCLUSION

1. Inheritance as expressed by heritability of immature fruit sizes (fruit width, length and weight), shape, fruit number per plant and yield were high.

2. Fruit number per plant of F_1 hybrid was higher than better parent. Other F_1 characters were recorded in the range between P1 and P2. Fruit sizes, fruit shape, fruit weight, and yield were expressed under quantitative inheritance.

3. Fruit number per plant was only one character that had high relationship to total yield of plant. The marketable fruit width, fruit length, fruit shape, and fruit weight did not affect the fruit number and yield per plant.

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