PERFORMANCE EVALUATION OF CUCUMBER (*Cucumis sativus*) RECIPROCAL HYBRID THROUGH MEASUREMENT HETEROSIS VALUES AND CLUSTER ANALYSIS

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ABSTRACT

Measurement of heterosis value and evaluate the yield and quality of cucumber to be developed into hybrid varieties was important information to saw the superiority of these plants before being released into hybrid varieties. This study aims to evaluated reciprocal hybrids through measurement of heterosis values and their level of similarity with parents. This research was conducted at Integrated Field Laboratory Unila with altitude of place ± 144 m above sea level in February to April 2016. This research was conducted by randomized block design with three replications. They treatment were a cucumber of Mercy parent, Toska parent, Mercy x Toska hybrid, Toska x Mercy hybrid. Data were tested with LSI 5% to saw the difference in performance of hybrids with parent and followed by calculating the value of heterosis and *cluster analysis.* The results of this study indicated that both hybrids had positive heterosis values on the length parameter of fruit, fruit diameter, weight per fruit, fruit weight per plant and fruit yield per hectare. Toska x Mercy hybrids had an advantage on the fruit sweetness level with positive heterosis values and more similar to Toska parent and better crispity than Mercy x Toska hybrid.

Keyword: Heterosis, Cucumber

INTRODUCTION

The plant breeding program in detail aims to assemble new varieties with high yield, good yield quality, improved agronomic characteristics, pest and disease resistance, and other properties. It is expected to contribute according to the criteria desired by the producers, consumers, and the breeders themselves (Allard, 1960). Plant breeding activities to form varieties with high yield properties, good yield quality, and others that meet the commercial criteria one of them was to develop hybrid varieties. Generation F_1 progeny was the result of crossbreeding of a pair or more parents pure strains that have a superior character (Syukur, et al., 2015).

The heterozygous genetic composition possessed by hybrid varieties makes this variety superior to non-hybrid varieties that had homozygous genetic

composition. Assembling of hybrid varieties that had superior agronomic character in plant breeding programs was by crossing two or more plants that have superior character. In assembling hybrid varieties that had the desired quality and quantity of agronomic character, it was necessary to had LSI test and how big the heterosis and heterobeltiosis of a plant as one reference to see the superiority of a hybrid.

The Least Significant Increase test was used to compare the performance between hybrid and parent. The LSI test was one-way so that it has a lower comparator value and the comparison results obtained from the LSI test were better because the differences shown between the treatments are more pronounced and the protection of the first type of mistake is very low (Peterson, 1994).

Heterosis was a visible improvement when two inbred lines or a particular variety were crossed. This increase was measured by calculating the difference F_1 rated *Mid parent* (average of parents) or from the parents superior value or so-called *Best parent* (Crowder, 1997). Heterosis information will be obtained through excellence value of an F_1 progeny of one of the best parent or an average of the two parents was seen from the appearance of agronomic $F_{1.}$ Large heterosis effect in a hybrid ($F_{1)}$ does not necessarily mean that these hybrids have a high yield. Therefore it was necessary to evaluate the hybrid ($F_{1)}$ are to determine the potential performance results and the ability of the parent to form a hybrid by utilizing heterosis effect (Hening, 2008).

To prove the explanation as mentioned above, in this research will be predicted heterosis value and hybrid power test result from reciprocal crossing of two varieties that was between Mercy and Toska in effort to assemble cucumber hybrid varieties that had superior character with special characteristic that was fruit Sweet, crispy fruit flesh, and high yield power. Mercy variety is typical cucumber or local type of cucumber for salad with special characteristics typical of dark green fruit color with light green fruit tip, sweet fruit with high soluble solid content, in terms of size of this type of cucumber had a relatively large fruit diameter and fruit length 20-25 cm, and fruit yield per hectare ± 70 tons / ha. Toska variety which was a type of japanese cucumber with special characteristic

that was dark green color completely and somewhat shiny, harvest age 45-48 hst fruit length could reach ± 30 cm, weight per fruit 350-400 g, and yield potential per hectare 50 -60 tons / ha (Riadi, 2015),

The purpose of this study was to evaluate hybids result of crossing reciprocally through the test LSI and heterosis, while getting hybrid with the quality of the fruit crispness and fruit sweetness, as well as to test the yield of cucumber hybrid cross of two varieties, namely between Mercy and Toska reciprocally.

METHODS

This research was conducted at Integrated Field Laboratory with altitude of place ± 144 m above sea level, Faculty of Agriculture, University of Lampung. The study was conducted from February to April 2016.

The study was prepared using a single unstructured treatment design with the cucumber genotype as the treatment of the parents of Mercy (A), Toska (B) parent, and the two crossing genotypes of Mercy x Toska (C) hybrids and Toska x Mercy hybrids (D) Is Randomized Block Design (RBD) with three replications. Each experimental unit consists of four plants that were plant samples.

The data obtained would be tested *Multivariate analysis* using Minitab 16 application, with displays dendrogam to saw the genetic relationship between the parents and the hybrid character brix levels, crispy fruit, fruit length, number of fruit per plant, weight per fruit and fruit weight per plant.

To compare the performance between hybrids and parents it was necessary to test the LSI *(Least Significant Increase)* 5%.
Formula :

$$LSI = t\alpha\sqrt{((2\ SM\ Error) / n)}$$

Description: tα = Value t one-way table of degrees free of SME; N = number of replay; SME = Squares middle error value; +: Hybrids higher than parents + LSI at α = 5%; -: Hybrids are lower than parents + LSI at α = 5% (Petersen, 1994).

Prediction analysis was used to determine the value of heterosis heterosis effect was based on the midpoint of the two parents *(Mid Parent)* and the midpoint best parents *(Best Parent)* or heterobeltiosis.

Heterosis formula (Mid Parent):

$$h = \frac{F1-(P1+P2)/2}{(P1+P2)/2} \times 100\%$$

Heterobeltiosis formula (Best Parent):

$$h = \frac{F1-BP}{BP} \times 100\%$$

Description: F_1 = hybrid; P_1, P_2 = parents 1 and 2; BP = the best parent (Falconer, 1989).

The parameters observed on quantitative components were flowering (day after planting), age of harvest (dap), fruit length (cm), fruit diameter (cm), number of fruits per plant, fruit weight per plant (kg / plant), weight per fruit (g) Results of fruit per hectare (ton/ ha), the crispness of fruit (kg / cm $^{2)}$ and brix levels.

RESULTS AND DISCUSSION

The results showed that the fruit length variables on Mercy x Toska hybrids and Toska x Mercy hybrids had positive values for the Mercy parent and the negative values for Toska parent in the 5% LSI test (Table 1). The value of hybrid second heterosis was positive to the average parent with the highest heterosis value of 10.46% achieved by Mercy x Toska hybrid (Table 2). This means both hybrids had longer fruits than the Mercy parent, but were shorter than the Toska parent and longer than the average of the two parents.

In the 5% LSI test for fruit diameter parameters indicated that the hybrid Mercy x Toska and Toska x Mercy hybrids had positive values from Toska parent (Table 1). The value of both hybrid heterosis was positive to the average parent with the highest heterosis value of 8.22% achieved by Mercy x Toska hybrid (Table 2). This means the two hybrids had a larger fruit diameter than the Toska

parent, but are smaller than the Mercy parent and were larger than the average of the two parents.

The achievement of the number of fruits per plant on both Mercy x Toska and Toska x Mercy hybrids was negative against both parents on the 5% LSI Test (Table 1). Meanwhile, the value of hybrid heterosis both positive to the average parent with the highest heterosis value of 10% is achieved by Mercy x Toska hybrid (Table 2). This means that the achievement of the number of crops on the Mercy x Toska hybrid was higher than the average of the two parents and more similar to that of the Mercy parent.

Both Mercy x Toska and Toska x Mercy hybrids had positive values compared to Mercy's parents of the LSI 5% test for weighted parameters per fruit (Table 1) and have positive heterosis and heterobeltiosis values with a 14.02% highest heterosis value achieved by Mercy x Toska hybrids And the highest heterobeltiotic value of 10.33 on Toska x Mercy hybrids (Table 2). This means that the achievement of weight per fruit on both hybrids was higher than both parents and the Toska x Mercy hybrid was quite similar to Toska's parent.

The 5% LSI test on the fruit weighting parameters of the plant shows that the hybrid Mercy x Toska and Toska x Mercy hybrids had positive values from both the parents of Mercy and Toska (Table 2). Both hybrids had heterosis and heterobeltiosis values of highest heterosis value of 28.21% and the highest heterobeltiosis of 17.02% was achieved by Mercy x Toska hybrids (Table 2).

The Toska x Mercy hybrid had a positive value of the Mercy parent but was negative to Toska parent for the fruit brix concentration in the 5% LSI test (Table 1) with a positive heterosis value of 1.57% against the average of both parents (Table 2). From the analysis of *clusters* on dendrogram graphic images (Figure 5) shows that the Toska x Mercy hybrid had a similarity rate of 49.426% with Toska parent with a lower Brix value than Toska parent.

Toska x Mercy hybrid achievement for crispness had positive value from Toska parent, but it is negative to Mercy parent. The heterosis value was positive 1.44% against the average of both parents. This means that the fruit crispness

achievement of the Toska x Mercy hybrid was tougher than the Toska parent and softer than the Mercy parent.

Both parents had positive heterosis value for fruit length variables, fruit diameter, number of fruit / plant, weight / fruit, fruit / plant weight, fruit weight / ha. This shows that the two hybrids in these variables had performance that exceeds the average of both parents. Increase or decrease in heterosis values may also indicated a genetic increase or decrease present in a hybrid (Vrahmana et al, 2013). This genetic improvement could be interpreted as the presence of the dominant gene genes of a character from the parently working well and complementarily to the hybrid. On the contrary, if genetic decline occurs, the dominant gene genes of a character of the parently did not work well and were complementary to the hybrid (Oktarisna et al, 2013). However, low heterosis values did not necessarily represent that the progeny of a crosses are bad (Robisalmi et al., 2010).

Mercy x Toska hybrid has hetrosis value of 28.21% for production variables. If there was a heterosis value above 20% in the production component, this was a great chance of success in assembling hybrid varieties (Kirana and Sofiari, 2007)

The interesting thing was seen in heterosis for the sweetness positive and negative reversed rate variables between hybrids of one another. Toska x Mercy hybrids had positive values for the variables the level of sweetness (Brix levels) and had a high degree of similarity with Toska parents, which differ on Mercy x Toska hybrids. The apparent differences between the two reciprocal hybrids were also suspected to had a meternal effect on the observed variables. According to Suryo (2004), the appearance of the variables was determined by the female parents who contribute more to the hybrid than the male parents, so that the progeny were closer to the female parents than the male parents. The influence of female parents was a pattern of inheritance of plant traits controlled by genes located outside the cell nucleus as in the cytoplasm, mitochondria of female parent cells (Susilo and Sari, 2011). Also suspected the influence of dominant diversity or epistasis. Dominant diversity was the result of interactions between alleles at

the same locus, whereas epistatic diversity was caused by the interaction of alleles at different loci (Waldmann, et al., 2008).

Based on production observations and fruit quality, the Toska x Mercy hybrid was superior to the Mercy x Toska hybrids and performance above the average parent.

CONCLUSION

Both hybrids had a positive heterosis value on the length parameter of fruit, fruit diameter, weight per fruit, fruit weight per plant and fruit yield per hectare. Toska x Mercy hybrid had an advantage on the fruit sweetness level with positive heterosis values and more similar to Toska parent and better crispness than Mercy x Toska hybrid.

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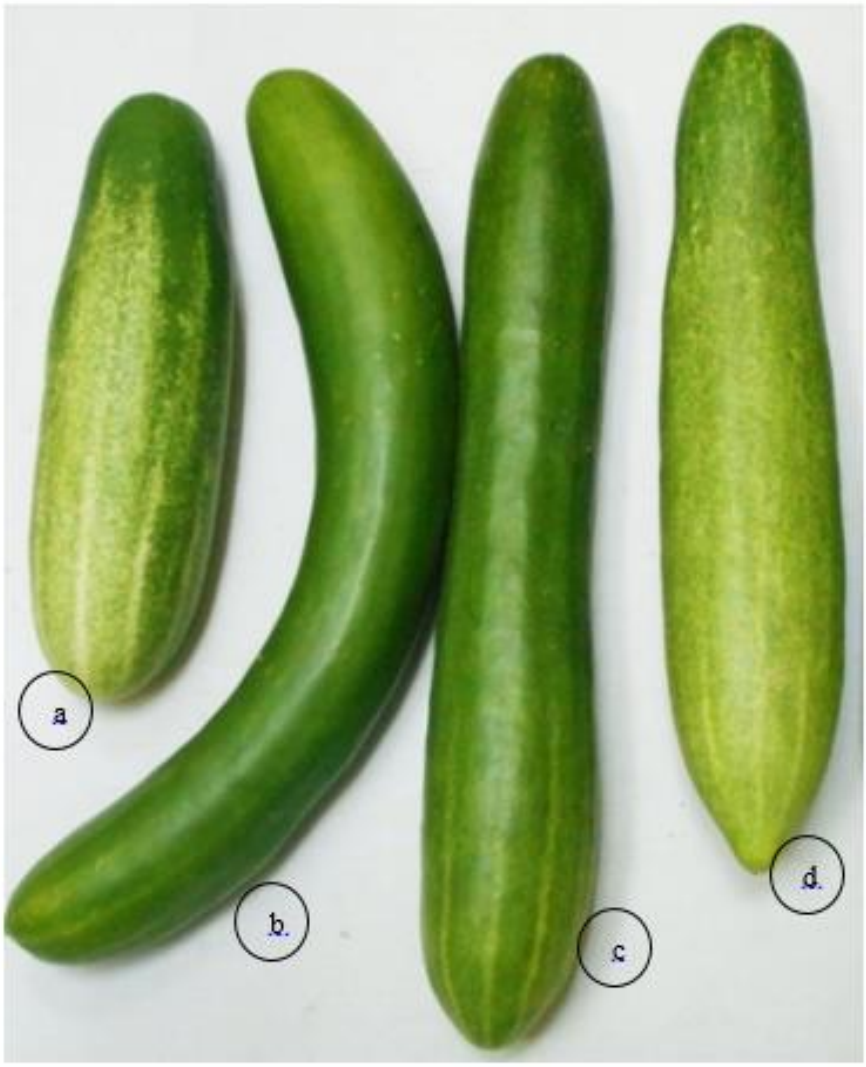


142C: Light green 141A: Dark Green 140B: Green

Pigure 1. Fruit color of the parents and hybrids, used *RHS Color Chart* (A: Mercy, B: Toska, C: Mercy x Toska Hybrid, D: Toska x Mercy Hybrid.

Table 1. LSI Test 5% generative parameters of both hybrid quantitative components.

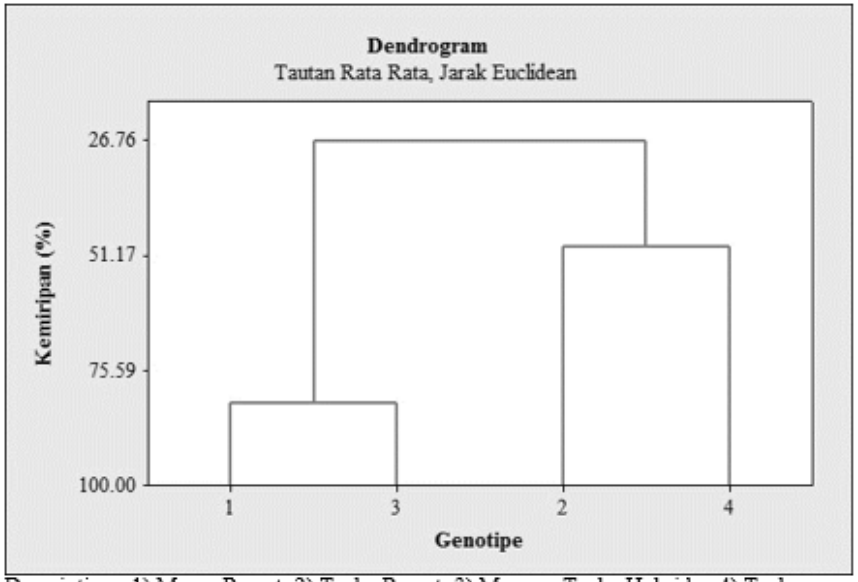
	Hybrid Mercy X Toska (C)	Hybrid Toska X Mercy (D)	Parent Mercy + LSI	C	D	Parent Toska + LSI	C	D
Age Flowering (dap)	30,12	30,5	30,17	-	+	32,09	-	-
Harvest Time (dap)	43,67	44,5	46,91	-	+	45,91	-	-
Fruit Length (cm)	28,72	26,96	23,04	+	+	31,31	-	-
Fruit Diameter (cm)	3,77	3,56	4,19	-	-	3,12	+	+
Number of Fruits/Plants	6,42	5,92	8,1	-	-	6,43	-	-
Weight/Fruit (g)	368,74	374,06	351,04	+	+	382,36	-	-
Weight of Fruit/Plants (kg/plant)	9,54	8,98	10,31	-	-	8,89	+	+
Weight of Fruit/Ha (ton/Ha)	99,42	93,477	107,42	-	-	92,60	+	+
Fruit Crunchy (kg/cm2)	5,3	5,14	6,07	-	-	4,91	+	+
Fruit Brix Content (%)	2,45	2,77	2,47	-	+	3,24	-	-

Description: (+) = Hybrids higher than parent + LSI at α = 5%; (-) = Hybrids lower than parent + LSI at α = 5%.

Table 2. Heterosis test (Mid Parent h) and heterobeltiosis (h Best Parent) second generative hybrid quantitative component parameters.

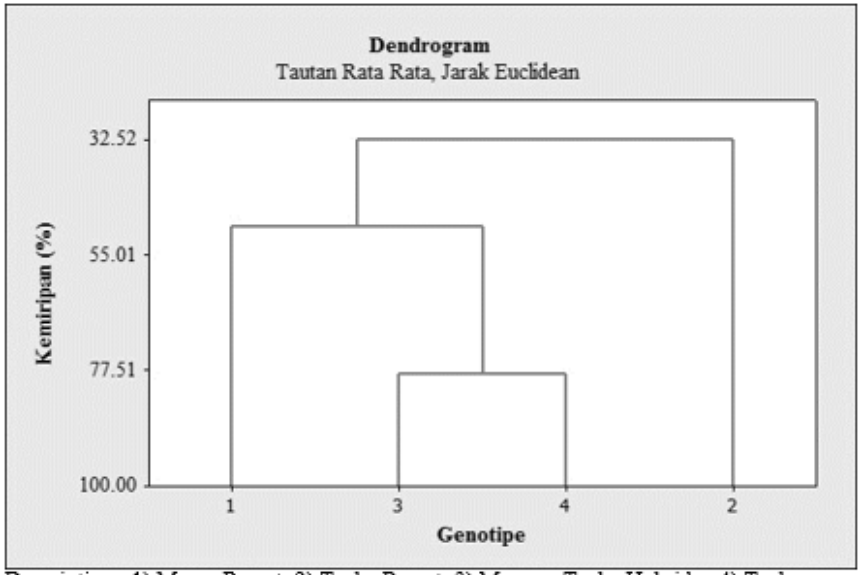
Parameter	Parent Mercy	Parent Toska	Hybrid C	Mercy X Toska (C)		Hybrid D	Toska X Mercy (D)	
				h*MP* (%)	h*BP* (%)		h*MP* (%)	h*BP* (%)
Age Flowering (dap)	44,75	43,75	43,67	- 0,69	- 3,72	44,50	+ 0,41	- 2,66
Harvest Time (dap)	21,86	30,13	28,72	- 1,32	- 2,42	26,96	+ 0,57	- 0,56
Fruit Length (cm)	4,02	2,95	3,77	+10,46	- 4,70	3,56	+ 3,35	- 10,53
Fruit Diameter (cm)	6,67	5,00	6,42	+ 8,22	- 6,14	5,92	+ 2,03	- 11,36
Number of Fruits/Plants	307,73	339,05	368,74	+10	- 3,75	374,06	+ 1,30	- 11,25
Weight/Fruit (g)	84,96	70,14	99,42	+14,02	+ 8,75	93,47	+13,74	+10,33
Weight of Fruit/Plants (kg/plant)	8,16	6,73	9,54	+28,21	+17,02	8,97	+16,01	+10,01
Weight of Fruit/Ha (ton/Ha)	5,79	4,63	5,30	+28,21	+17,02	5,14	+16,01	+10,01
Fruit Crunchy (kg/cm2)	2,33	3,10	2,45	- 10,36	- 21,48	2,77	+ 1,57	- 11,17
Fruit Brix Content (%)	5,79	4,63	5,30	+ 1,44	- 8,75	5,14	- 1,29	- 11,22

Description: (+) = Hybrid performance is higher than the parent; (-) = Hybrid performance is lower than the parent.



Description : 1) Mercy Parent; 2) Toska Parent; 3) Mercy x Toska Hybrids ; 4) Toska x Mercy Hybrids

Figure 2. Dendrogam parents and hybrids of fruit soluble solid concentration.



Description : 1) Mercy Parent; 2) Toska Parent; 3) Mercy x Toska Hybrids ; 4) Toska x Mercy Hybrids

Figure 3. Dendrogam parents and hybrids fruit crisp variables.

Tabel 3. Cluster analysis of soluble solid of fruit between parents and hybrids

Class number	The level of similarity (%)	Distance level	Genotype
3	82,4	0,65	1 dan 3
2	49,26	1,88	2 dan 4
1	26,76	2,72	1 dan 2

Description : 1) Mercy Parent; 2) Toska Parent; 3) Mercy x Toska Hybrids ; 4) Toska x Mercy Hybrids

Tabel 4. Cluster analysis of fruit crisp between parents and hybrids

Class number	The level of similarity (%)	Distance level	Genotype
3	78,04	0,91	3 dan 4
2	49,32	2,10	1 dan 3
1	32,52	2,79	1 dan 2

Description : 1) Mercy Parent; 2) Toska Parent; 3) Mercy x Toska Hybrids ; 4) Toska x Mercy Hybrids