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Research Article

Similarity Appearance of Parents with Progeny of Lombok Local Cantaloupe (*Cucumis melo* var. Cantalupensis) and Melon (*Cucumis melo* L.)

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Abstract: Crosses between local lombok cantaloupe and melon have produced the first progeny (F1). The F1 have a similar appearance to their parents. This study used two similarity assessments based on qualitative and quantitative traits. Qualitative characters are said to have similarities if their phenotypic appearance resembles one or both parents. The similarity of qualitative characters is visually observed using the munsell plant tissue color book and penetrometer. Meanwhile, the quantitative characters are said to have an appearance resembling one or both parents if the standard error line at the histogram between parents and offspring overlaps. In addition, analysis of gene action, heterosis, heterobeltiosis, and the maternal effect was carried out on quantitative character to obtain genetic information for producing superior local lombok cantaloupe varieties. The results of this study showed several changes in the appearance of F1 in qualitative and quantitative characters. The qualitative characters of F1 resemble the female parent, while the quantitative characters do not resemble both parents. Genetic information about potential ratio, heterosis, heterobeltiosis, and maternal effect varied. Gene action is dominated by potency ratio partial dominance and overdominance. Heterosis occurred in all treatments, while heterobeltiosis did not occur in all treatments. The maternal-effect was obtained on fruit weight, fruit diameter, and fruit length characters.

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1. Introduction

Lombok local cantaloupe has the advantages of having soft flesh, being rich in nutrients, and being tolerant of drought and pest diseases (Sholihatin, 2020). The weakness is that the fruit taste is not sweet, so it has low economic value. Plant crosses between local lombok cantaloupe and melon were carried out to combine the genes controlling the superior traits of the two parents. In this crossing, it is hoped that there will be genetic improvements in the lombok local cantaloupe so that the fruit becomes sweet while maintaining its advantages and increasing its economic value. The contribution of this cross is prioritized in its contribution to economic value (Şener and Kaya, 2022). To compete with imported fruit, it is necessary to improve the quality of local plants by developing lombok local cantaloupe (Muhammadi and Daryono, 2022).

Crosses between lombok local cantaloupe and melon produce progeny with high diversity. The diversity of characters is divided into two categories, namely the diversity of qualitative and quantitative traits. Qualitative traits can be clearly distinguished simply by observing the appearance of the plant. It happens because the genes that control the formation of traits appear to be controlled by a single gene with a main effect that is easy to recognize, (Carsono et al., 2022). While quantitative traits cannot be clearly distinguished just by looking at the appearance of the plants, an analytical method is needed to predict the traits that appear in the plants observed. It happens because so many genes are involved that the distribution will be continuous (Ikram and Chardon, 2010).

The appearance of progeny resulting from crosses can be seen by determining the type of gene action, the value of heterosis and heterobeltiosis, and observing the maternal effects of the reciprocal progeny. Gene action describes the relationship between plant genes, which is then expressed into the phenotypic appearance of the plant. An understanding of gene action could provide an overview of the appearance or phenotype of the plant that will be formed. Knowledge of gene action is also important to determine the type of plant variety to be made. Information about the gene action of a character is important to know as early as possible to facilitate the breeding program being carried out (George et al., 2022). This is because it will help accelerate the development of new superior varieties. In addition, information about gene action can also make breeding programs more effective and efficient (Sharma et al., 2013). Another function of gene action information is to determine the appearance of the phenotype in the progeny of plant crosses. The difference in phenotypic appearance in each progeny is caused by the different gene actions resulting from crosses. Analyzing gene action can also determine whether there is heterosis (Jafri et al., 2022). Heterosis is a phenomenon in which the appearance of the first progeny from crosses (F1) is better than the two parents (Kotkar and Giri, 2020). This phenomenon is beneficial for plants in reproduction and adaptation to environmental changes. Generally, plants with high heterosis will be directed to developing new hybrid superior varieties (Liu et al., 2020).

The appearance of characters passed from parents to progeny can occur in two mechanisms, namely chromosomal inheritance (nucleus) and extrachromosomal inheritance. Extrachromosomal inheritance is an inheritance that is controlled by genes that exist outside the cell nucleus. One of the characteristics of this inheritance is that the progeny of the crosses is different from the progeny of the reciprocal crosses, so it can be said that extrachromosomal inheritance is the result of the maternal effect. The maternal-effect is a modification of the appearance of progeny that resembles the appearance or characteristics of female parents (Schwabl and Groothuis, 2019). This happens because the inheritance of plant characters is not only formed due to genetic factors that exist in the cell nucleus and the environment where the plant grows but can be influenced by the maternal effect (Gilsinger et al., 2010; Badiaraja et al., 2021).

The objectives of this study are 1) to determine changes in the appearance of the first progeny from crosses of lombok local cantaloupe (F1) towards their parents and 2) to determine genetic information about pattern inheritance of traits on progeny using gene action, heterosis, heterobeltiosis, and maternal effect.

2. Material and Method

2.1 Plant material and plantation area

The materials used in this study were seeds of lombok local cantaloupe (endes), a pure line of golden melon, the first progeny resulting from crosses of lombok local cantaloupe and melon, and the reciprocal first progeny obtained from the germplasm collection of the Faculty of Agriculture, University of Mataram. The research carried out consisted of 4 treatments, namely P1 (local lombok cantaloupe/endes), P2 (melon), F1, and F1Rs. Each treatment was repeated 6 times to obtain 24 experimental units. Each experiment was planted with 6 plants to obtain a population of 144 plants.

This research was conducted in August - November 2022 in Peresak Village, Narmada District, West lombok Regency, West Nusa Tenggara Province. The height of this place is 136 meters above sea level. The average environmental conditions are rainfall reaching 546mm, temperature 21ºC - 32ºC, and humidity 4% - 96%.

2.2 Methods

2.2.1 Similarity appearance

Observation of similarity in the appearance of the qualitative characters criteria in this study included fruit shape, fruit skin color, fruit flesh color, and fruit texture (Sirojuddin et al., 2015). The qualitative character data was obtained visually for fruit shape character and using a Munsell Plant Tissue Color Book for fruit color and a penetrometer for fruit texture. The quantitative characters are observed, namely plant age, plant height, stem diameter, fruit weight, fruit diameter, fruit length, fruit thickness, and sweetness level (brix%). The similar appearance of the quantitative characters is observed by looking at the standard error line in the histogram. The standard error formula is as follows (Cumming et al., 2007):

$$SD=\sqrt{\frac{\sum (X-M)^2}{n-1}} \quad (1)$$

Where:
SD = Standard error/standard deviation
X = Individual Data
M = Means

When the standard error line at the histogram between progeny and parents that are compared is overlapped, then there is a similar appearance, but if the standard error line of the histogram does not overlap, then there is no similar appearance in that character (Cumming et al., 2007).

2.2.2 Gene action

Gene action is based on the degree of dominance calculated from the value of the potential ratio of Peter and Frey (1966) in Woelan et al. (2015) which is formulated as follows:

$$hp=\frac{mF-MP}{BP-MP} \quad (2)$$

Where:
hp = potency ratio (gene action)
mF = mean value of progeny
MP = the average value of the two parents (mid-parent value)
BP = the best parent mean value

Based on the calculation results above, it could be estimated that gene action on several quantitative characters from crosses based on the value of the potential ratio that reflects the degree of dominance is as follows:
hp = 0, additive gene action (no dominance)
hp = +1 or -1, positive or negative dominant gene action (complete dominance)
hp = -1<hp<0 or = 1>hp>0, negative or positive partial dominance (incomplete dominance)
hp = >+1 or <-1, dominant gene action is more positive or negative (overdominance)

2.2.3 Heterosis and heterobeltiosis

Heterosis and heterobeltiosis were estimated as per the following formula suggested by Lakshman et al., (2018).

$$H\%=\frac{mF-MP}{MP}\times 100\% \quad (3)$$

$$HB\% = \frac{mF\text{-}BP}{BP} \times 100\% \tag{4}$$

Where:
H% = heterosis
HB% = heterobeltiosis
mF = mean value of progeny
MP = the average value of the two parents (mid-parent value)
BP = the best parent mean value

2.2.4 Maternal effect

The genetic information of maternal effect on quantitative characters an analysis using paired t-test. The paired t-test formula is as follows (SAS, 2016):

$$t = \frac{\bar{d}}{\frac{sd}{\sqrt{n}}} \tag{5}$$

Where:
$\bar{d}$: the average difference in paired data
sd: standard deviation

$$sd = \sqrt{\frac{\sum d^2 \frac{(\sum d)^2}{n}}{n-1}} \tag{6}$$

n: total of sample

3. Result and Discussion

3.1 Similarity appearance

Inheritance of traits to progeny resulting from crosses can be in the form of qualitative traits or quantitative traits. Qualitative traits are generally controlled by a single gene and characterized by a clear phenotype or character appearance. In contrast, quantitative traits or characters are controlled by many genes and display phenotypic variations continuously (Rukundo et al., 2018). This is possible because the quantitative character of the role of the variety of the environment is also relatively large compared to the qualitative character. This is in accordance with the statement (Qi et al., 2015) that quantitative character is controlled by many genes, and the appearance of the character is strongly influenced by environmental factors. Quantitative characters are characters that can be measured using numbers such as flowering time, number of seeds, plant age, and plant resistance (Song et al., 2018). Unlike the case with qualitative characters that cannot be measured with numbers, such as fruit color, leaf color, stem color, fruit shape, and fruit texture (Kiramana and Isutsa, 2017). This happens because the qualitative characteristics of plants are controlled by one gene or major gene (genes that follow Mendel's laws), so the role of environmental variation is relatively smaller (Carsono et al., 2022). Qualitative character observations in this study included fruit shape, fruit color, and fruit texture (Table 1). The appearance of the fruit shape (Figure 1) in the P1 line has an oval shape, while the P2 has a slightly round shape. Crosses between cantaloupe and melon produce F1 with an oval fruit shape. The shape of fruit of the *Cucumis melo* plant generally has a round or oval fruit shape, depending on the sub-species (Mariod et al., 2017). The shape of the cantaloupe bears a resemblance to the gourd, which is oval, but some are round (Zawani et al., 2017).

Table 1. Observation results of qualitative characters

Treatment	Fruit Shape	Fruit Skin Color	Fruit Flesh Color	Fruit Texture
P1	Oval	Green Yellow	Green Yellow	Soft
P2	Slightly Rounded	Yellow	Yellow-Red	Hard
F1	Oval	Green Yellow Yellow	Green Yellow Yellow	Slightly Hard

Note: Soft (<1.5), slightly hard (1,.5-2.75), and hard (2.75<).

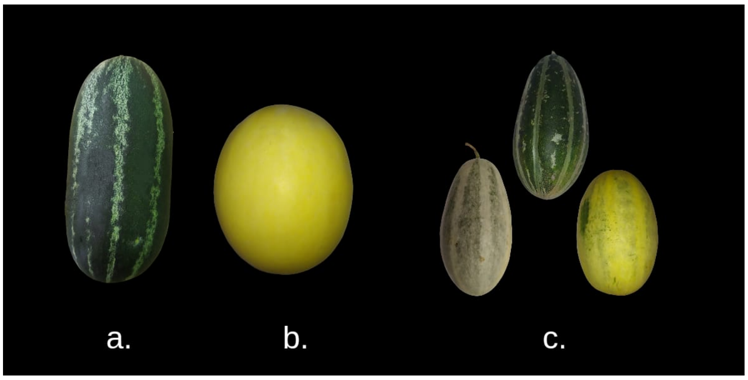

Figure 1. Observation of fruit shape and skin color: a. Female parent (P1), b. Male parent (P2), and first progeny resulting from crosses of lombok local cantaloupe and melon (F1).

Figure 2. Observation of fruit flesh color: a. Female parent (P1), b. Male parent (P2), and first progeny resulting from crosses of lombok local cantaloupe and melon (F1).

The fruit's skin and flesh color appearance is one of the parameters for the diversity of qualitative characters (Table 1). The skin and flesh fruit color characters were measured using the Munsell plant tissue color chart. The female parent (P1) has a green-yellow skin color, while the male parent has a yellow fruit skin color. The cross's progeny have various colors, but most of the fruit has a yellowish-green skin color, and some are yellow. However, the F1 has a stripe pattern that more closely resembles the P1. Similar appearance to the color of the flesh of the fruit (Figure 2), the color of the flesh of the P1 fruit has a green-yellow character, where the color of the flesh is dominated by a yellowish green color. The color of P2 fruit flesh has a yellow-red character, where the color of the flesh is dominated by reddish yellow or orange. The color of F1 fruit flesh has various color characters, namely green-yellow and yellow. The color of the flesh of the first generation is dominated by the hue green-yellow. This means that the progenys' appearance tends to resemble the female parent (P1). Muhammadi and Daryono (2022) obtained the same results, who observed the qualitative characteristics of the progeny from crosses between Kinanti and Sonya. The crosses resulted in a Kinaya line with greenish-yellow fruit skin color. The skin color of the Kinaya fruit is more similar to that of the female parent, namely Kinanti than the male parent of Sonya. The fruit color character shows that the progeny from crosses between Kinanti (female parent) and Sonya (male parent) have the color of the flesh resembling the female parent, namely RHS 22D or light reddish yellow. Observation of phenotypic characters in the first generation is important for researchers. This information is useful in optimizing genetic resources as materials in plant breeding activities. In addition, observing the appearance can be used as a basis for selection (Akinyosoye, 2022).

The similarity of each quantitative character across the various treatments (Figure 3). In terms of plant age, it is known that F1 were not similar to those of their two parents. In the characters of plant height, stem diameter, and fruit length, F1 had similar characteristics with female parents (P1). The characteristics of fruit weight, fruit diameter, fruit thickness, and sweetness level in F1 were not similar to those of their two parents. This means that the similarity in the appearance of quantitative characters with their parents varies. In addition, it is known that F1 has a dissimilar tendency in quantitative characters to its two parents. The similarity in the appearance of the characters resulting from crosses is inherited from the two parents. Another study by Muhammadi and Daryono (2022) regarding the similarities in the characters of progeny from crosses with their parents showed that crosses between Kinanti and Sonaya produced Kinaya F3 and F4, which have a variety of similar characters. In the stem length or plant height characters, there are similarities in the Kinaya characters F3 and F4 to their parents. As for the diameter of the Kinaya stem, F4 has similarities to the two parents, but F3 does not resemble the two parents. In addition, on fruit characteristics such as fruit weight, fruit length, fruit diameter, and level of sweetness, there are similarities in the characteristics of Kinaya F3 and F4 to the two parents. This occurs due to segregation in the process of meiosis which causes the genes at a locus to separate, and each can form different gametes so that different combinations are possible, which cause different genotypes of the progeny (Zielinski and Scheid, 2012; Datta et al., 2015).

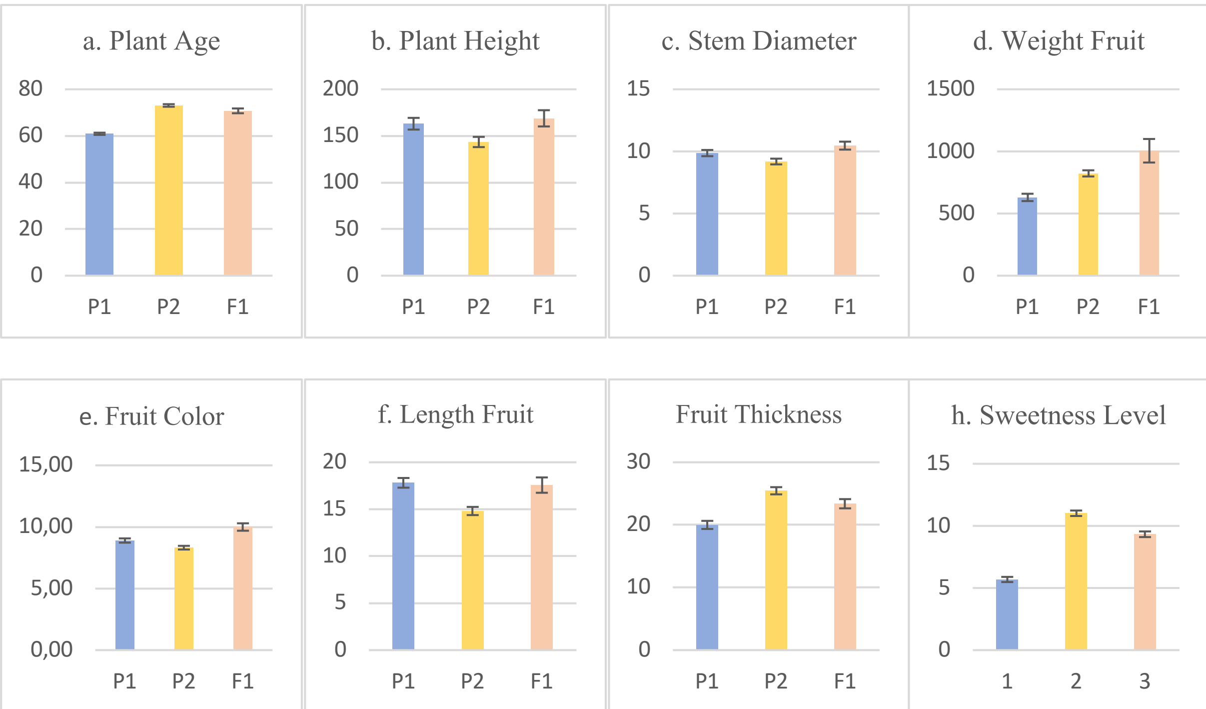

Figure 3. Histogram similar appearance of quantitative character F1 and parents.

3.2 Genetic information

This information is important in planning a plant breeding program. Inheritance information can be known by calculating the value of gene action, heterosis, heterobeltiosis, and maternal effect (Rachman et al., 2022). Gene action provides an overview of the relationship between the genes present in a plant which is then expressed into a phenotypic appearance for the plant. So, differences in gene action in each plant will give a different appearance. According to Hossain (2017), gene action refers to the role of several genes that influence the appearance of plants.

The potency ratio is a value used to determine gene action in progeny resulting from crosses. Research conducted by Rohman et al. (2019) concluded that the value of the potency ratio is important to know to estimate the level of dominance of genes that play a role in the inheritance of plant traits. Based on the results of the analysis, it is known that there are levels of potency ratio values in all treatments. Most potency ratio values are affected by the action of overdominant and partially dominant genes (Table 5). The characteristics of plant height, stem diameter, fruit weight, and fruit diameter have a more positive dominant potential ratio (Overdominant). Overdominance is an intra-allele interaction in which the presence of multiple alleles results in a performance greater than homozygosity for one of the allelic states (Ghosh et al., 2018). While the treatment of plant age and level of sweetness has a partially negative dominant potential ratio, the treatment of fruit length and fruit thickness has a partially positive potential ratio. According to Frizzell (2013), partial dominance or incomplete dominance results from crosses in which each parent contribution is genetically unique and gives rise to progeny with an intermediate phenotypic appearance or similar between the two. According to Krisnawati and Adie (2022), the overdominance phenomenon in the crossing performance of a population will be different due to selection, and there will be an increase in the homozygosity of alternative alleles in the population to maximize heterozygosity and population crossing performance. Inheritance of character traits with the phenomenon of overdominant gene action is better directed to form hybrid varieties. As opposed to partially dominant, the average dominance degree will decrease, and most of the loci contributing to heterosis will most likely be coupled with a repulsion phase relationship. Therefore, treating plants with partially dominant gene action is better directed at forming synthetic varieties.

Table 2. Calculation results of gene action

Observed Characters	hp	Description
Plant Age	-0.61	Dominance Partial
Plant height	1.52	Over dominant
Stem Diameter	2.37	Over dominant
Fruit Weight	3.02	Over dominant
Fruit Diameter	4.77	Over dominant
Fruit Length	0.76	Dominance Partial
Fruit thickness	0.25	Dominance Partial
Sweetness Level	-0.32	Dominance Partial

Note: potency ratio: additive (0), dominant (+1/-1), dominant partial (0-1/-1-0), overdominant (>1).

Table 3. Calculation results of heterosis and heterobeltiosis

Observed Characters	Heterosis (%)	Heterobeltiosis (%)
Plant Age	5.38	-3.25
Plant height	11.48	3.66
Stem Diameter	6.87	3.85
Fruit Weight	38.53	22.85
Fruit Diameter	16.44	12.56
Fruit Length	7.21	-2.04
fruit thickness	2.9	-7.75
Sweetness Level	10.41	-16.81

Note: + = There is an increase in character than the average parents or better parents, - = There is no increase in character than the average parents or better parents.

Heterosis is a phenomenon that arises when the progeny of various varieties of a species or the result of crosses between species show a superior character or appearance that is greater than the average of the two parents. Meanwhile, heterobeltiosis is a phenomenon that arises when progeny are better than their best parents (Orton, 2020). The heterosis value describes the superiority of the progeny from the cross over the average of the two parents. Meanwhile, the heterobeltiosis value describes the superiority of the progeny from crosses above the average of the best parents (Krisnawati and Adie, 2022). The results of observations of heterosis and heterobeltiosis values for all treatments varied (Table 3). Heterosis values for all treatments ranged from 2.9% to 38.53%. In all treatments, there is the phenomenon of heterosis, with the lowest heterosis value in the treatment of fruit thickness and the highest in the treatment of fruit weight. Heterobeltiosis values in all treatments ranged from -16.81 to 22.85. This means that several treatments do not experience the phenomenon of heterobeltiosis, namely plant age, fruit length, fruit thickness, and level of sweetness. For the treatment of plant height, stem diameter, fruit weight, and fruit diameter have experienced the phenomenon of heterobeltiosis.

Table 4. Calculation results of T-calc.

Observed Characters	t-calc.	Description
Plant Age	1.04	There is no Maternal Effect
Plant Height	2.08	There is no Maternal Effect
Stem Diameter	0.89	There is no Maternal Effect
Fruit Weight	5.75	Maternal Effect
Fruit Diameter	5.83	Maternal Effect
Fruit Length	3.61	Maternal Effect
Fruit Thickness	0.61	There is no Maternal Effect
Sweetness Level	0.17	There is no Maternal Effect

Note: t-table = 2.57, if t calc. > t table =there is maternal effect if t calc. < t table. = there is no maternal effect

The maternal-effect is a condition in which the appearance of progeny is influenced by the genotype and phenotype of the female parent (Singh et al., 2017). According to Doutrelant et al. (2020), the maternal effect is a non-genetic mechanism in which the progeny phenotype is affected by the environment experienced by the female parent. Based on the results of the calculation of the paired data t-test, it is known that the calculated t-values vary (Table 4). The paired t-test is calculated by comparing the reciprocal F1 value with F1. For the treatment of plant age, plant height, stem diameter, fruit thickness, and sweetness level, the value of t count < t table at 5% level. This means that in this treatment, there was no maternal effect. The treatment of fruit weight, fruit diameter, and length has a value of t count > t table 5%, which means there is a maternal effect in this treatment. Research conducted by Nurhidayah et al. (2021) found a maternal effect on the treatment of the length, width, thickness, and color of the rice grains. This means there is a maternal effect on the value of the treatment. The influence of female parents indicates that the inheritance of traits to their progeny is extrachromosomal or cytoplasmic. Cytoplasmic or extrachromosomal inheritance occurs outside the nucleus, resulting in the increased resemblance between female parents and their progeny compared to male parents (Wolf and Wade, 2009 and 2016).

Conclusion

In conclusion, the qualitative characteristics of F1 were similar to the female parents in fruit shape and fruit color. The fruit texture character has no resemblance to the two parents. Most of the F1 quantitative characters do not resemble the two parents but have a higher value, so there is a heterosis effect on all characters. The value of the potency ratio for the character of plant age, fruit length, fruit thickness, and sweetness level, which is partially dominant, is more suitable for developing synthetic varieties. The potency ratio is overdominant for the characters of plant height, fresh fruit weight, and fruit diameter, so it is more suitable for developing hybrid varieties. In addition, the characteristics of fruit weight, fruit length, and fruit diameter were influenced by female parents. This means that the inheritance of nature is extrachromosomal.

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