THE SELECTION AND COMBINING ABILITY TEST OF MELON LINES

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นางสาวจิราพร เจนวิถี

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิทยาศาสตรมหาบัณฑิต

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THE SELECTION AND COMBINING ABILITY TEST OF MELON LINES

Suranaree University of Technology has approved this thesis submitted in partial fulfillment of the requirements for a Master's Degree.

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คำสำคัญ: กาเลียเมล่อน/สมรรถนะการผสม/ความดีเด่นเหนือกว่าพ่อแม่/การผสมแบบพบกันหมดโดยไม่สลับพ่อแม่/การปรับปรุงพันธุ์แตงเทศ

ปัจจุบันประเทศไทยนำเข้าเมล็ดพันธุ์เมล่อนเป็นจำนวนมาก เนื่องจากเกษตรกรไทยส่วนใหญ่นิยมปลูกเมล่อนเชิงพาณิชย์ด้วยเมล็ดพันธุ์ลูกผสม (F_1) ดังนั้นวัตถุประสงค์ในการทำวิจัยครั้งนี้ 1) เพื่อสกัดสายพันธุ์แท้ 2) เพื่อทดสอบสมรรถนะของสายพันธุ์เพื่อนำไปผลิตลูกผสม โดยแบ่งเป็น 2 การทดลอง ได้แก่ การทดลองที่ 1 การสกัดสายพันธุ์แตงเทศพันธุ์กาเลีย 2 สายพันธุ์ คือ กาเลียเนื้อสีเขียวและกาเลียเนื้อสีส้ม โดยทำการคัดเลือกสายพันธุ์จากชั่วที่ 3 จนถึงชั่วที่ 5 ด้วยวิธีการผสมตัวเอง จากการทดลองได้พันธุ์กาเลียเนื้อสีเขียว 5 สายพันธุ์ และพันธุ์กาเลียเนื้อสีส้ม 7 สายพันธุ์ สำหรับการทดลองที่ 2 การทดสอบสมรรถนะของสายพันธุ์เพื่อนำไปผลิตลูกผสม โดยการนำพันธุ์กาเลียเนื้อสีเขียว 5 สายพันธุ์ (A1, A2, A3, A4, A5) และพันธุ์กาเลียเนื้อสีส้ม 7 สายพันธุ์ (B1, B2, B3, B4, B6, B7, B8) มาผสมแบบพบกันหมดโดยไม่สลับพ่อแม่ (half diallel cross) ตามวิธีของ Griffing (1956) method 2 Medel 1 แล้วนำลูกผสม F_1 มาปลูกทดสอบร่วมกับพ่อ-แม่ วางแผนการทดลองแบบสุ่มสมบูรณ์ (CRD) 3 ซ้ำ จากการทดลองพบว่า ในพันธุ์กาเลียเนื้อสีเขียว สายพันธุ์ที่มีสมรรถนะการรวมตัวทั่วไป (GCA) ของลักษณะผลและผลผลิตสูง คือ A2 และในพันธุ์กาเลียเนื้อสีส้ม สายพันธุ์ที่มีสมรรถนะการรวมทั่วไป (GCA) ของลักษณะผลและผลผลิตสูง ได้แก่ B2 และ B3 สำหรับสายพันธุ์ที่มีสมรรถนะการรวมตัวจำเพาะ (SCA) และ heterosis ของลักษณะผลและผลผลิตสูง ได้แก่ A12, A14, A23 และ A24 ในพันธุ์กาเลียเนื้อสีส้ม สายพันธุ์ที่มีสมรรถนะการรวมตัวจำเฉพาะ (SCA) และ heterosis ของลักษณะผลและผลผลิตสูง ได้แก่ B12, B18, B27, B34 และ B78 สำหรับการศึกษาสหสัมพันธ์ (correlation) ระหว่างองค์ประกอบผลและผลผลิต พบว่าลักษณะผลผลิต ได้แก่ น้ำหนักผล ความกว้าง-ยาวของผล ความหนาเนื้อ และเปอร์เซ็นต์เนื้อ มีสหสัมพันธ์ทางบวก ในขณะที่ลักษณะความหนาเปลือก มีสหสัมพันธ์ทางลบกับลักษณะเปอร์เซ็นต์เนื้อ ซึ่งข้อมูลเหล่านี้เป็นประโยชน์สำหรับแนวทางการพัฒนาแตงเทศลูกผสมพันธุ์ใหม่ในโครงการปรับปรุงพันธุ์แตงเทศต่อไป

สาขาวิชาเทคโนโลยีการผลิตพืช | ลายมือชื่อนักศึกษา จิราพร เจนวิถี
ปีการศึกษา 2565 | ลายมือชื่ออาจารย์ที่ปรึกษา ____________

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Keyword: Galia melon/Combining ability/Heterosis/Half diallel cross/Melon Breeding

Currently, Thailand is importing more melon seeds. Most Thai farmers grow melons commercially using F_1 hybrids. Therefore, the objectives of this research were to investigate the inbred lines selection and combining ability test of line to produce F_1 hybrids. The experiment was divided into 2 parts. The first experiment selected inbred lines of 2 varieties of galia melon consisting of green flesh galia melon and orange flesh galia melon. The inbred lines selection was selected from F_3 hybrids to F_5 hybrids by self-pollination. The results showed that there were 5 lines obtained green of fleshed galia melon, and 7 lines of orange fleshed galia melon. For the second experiment combining ability test of line to produce hybrids. There were 5 lines of green fleshed galia melon (A1, A2, A3, A4, A5) and 7 lines of orange fleshed galia melon (B1, B2, B3, B4, B6, B7, B8) for into each line. The combining ability was analyzed using diallel cross design method II model I of Griffing (1956) and then, the planting test of F_1 hybrids were compared with parents. The experiment was conducted in CRD with 3 replications. The results showed general combining ability (GCA) and found A2 line had high GCA in yield characteristics in green flesh galia melon and B2 and B3 lines had high GCA in yield characteristics in orange flesh galia melon. The specific combining ability (SCA), heterosis of F_1 hybrids and found hybrids A12, A14, A23 and A24 had high SCA and heterosis in yield characteristics in green flesh galia melon. The orange flesh galia melon found hybrids B12, B18, B27, B34 and B78 had high SCA and heterosis in yield characteristics. The correlation coefficient analysis of fruit component and yield showed a positive correlation in fruit weight, fruit width-length, fruit pulp thickness and percentage of pulp. While fruit peel thickness showed negative correlation with a percentage of pulp. The study could be useful for the development of new hybrid melons in the melon breeding program.

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LIST OF ABBREVIATIONS

GG	=	Green-fleshed galia melon
GO	=	Orange-fleshed galia melon
GCA	=	General Combining Ability
SCA	=	Specific Combining Ability
H	=	Heterosis
HB	=	Heterobeltiosis
FWe	=	Fruit weight (kg)
FWi	=	Fruit width (cm)
FL	=	Fruit length (cm)
FCW	=	Fruit cavity width (cm)
FCL	=	Fruit cavity length (cm)
FPuT	=	Fruit pulp thickness (cm)
FPeT	=	Fruit peel thickness (cm)
TSS	=	Total soluble solid (brix)
Fn	=	Firmness (N)
PFP	=	Percentage of fruit pulp (%)

CHAPTER I

INTRODUCTION

1.1 Background problem and significance of the study

Melons (melon, muskmelon, cantaloupe) was a plant family *cucurbitaceae*, that can adapt and grow well in hot and dry areas, with full sun light throughout the day. With sweet flavor, a good smell and prize, melons are in high demand on the market. Galia muskmelon (*Cucumis melo* L. var. *reticulatus* Ser.) is a popular melon, with yellow skin and have green or orange flesh, fragrant and sweet. It was developed by Zvi Karchi, an Israeli breeder, and was released in 1973 (Karchi, 2000). In 2021, it was reported that Thailand had 480.78 kilogram of melon seed imports, worth 4 million baht (The Office of Agricultural Regulation, 2021). Seeds are most imported, because at present most of Thai farmers prefer to grow commercial melons with F_1 hybrid provided high productivity, with some outstanding characteristics and consistency in various aspects. However, hybrid seeds are expensive, and they need to buy seeds every season. If the major melon growers in Thailand can produce their own seeds, they will be able to reduce seed costs significantly. The production of hybrid seed required a good parent line that have the desired characteristics for the market such as fruit peel color, pulp color, mesh, slip, sweetness, and weight, etc. Inbred line extraction from existing commercial varieties that can be produce using self-pollination at least 6 - 8 generations continuously to get high genetic stability. Therefore, the objective of this research is to select the parent line to create a hybrid population.

1.2 Research objectives

1.2.1 Inbred line selection of galia melon original varieties from F_3 hybrid to F_6 hybrid to create inbred line.

1.2.2 Combining ability test using half-diallel cross method to produce hybrid.

CHAPTER II

LITERATURE REVIEWS

2.1 Importance and cultivation of melons in Thailand

The scientific name of melon is *Cucumis melo* L., belonging to the family *Cucurbitaceae.* The number of chromosomes 2n=24. It's a cross pollinated crop by insects and wind but high self-pollination in cultivars with perfect flowers (Khanobdee, 1998). Melon was high-yielding economic crop and likely to increase of the market demand. However, the commercial was production of melon often has a problem with the accumulation of diseases and insects when the melon is continuously grown (Tira-umphon, 2000). Melon was popular fruit grown many more of Thailand's provinces, including Khon Kaen, Chiang Mai, Buriram, and others, with a tendency to expand further, because it was popular in the general market and supermarkets. Melon was eaten as a fresh fruit, due to the sweetness, aroma, and good taste. Farmers can grow melons for extra income, and good quality products will have a high price (Department of Agricultural Extension, 2016). In addition, melon was the fruit with highest beta-carotene content the human body needs and converts beta-carotene into vitamin A. Molon was rich in vitamin C that the human body needs for body functions. It was also protecting us from colds, cancer, and heart disease (Charlotte, 2007). In 2021, Thailand had 480.78 kilogram of melon seed imports, more than 4 million baht (The Office of Agricultural Regulation, 2021). Many seeds were imported because nowadays most Thai farmers prefer to grow melons commercially with hybrid seeds, because of high productivity. There were some characteristics that stand out and was consistent in various ways.

Galia melon (Cucumis melo L. var. reticulatus Ser.) was one popular variety of grow. It has the following characteristics: an average weight of 1 kilogram, a rounded shape, a thick net, a rough surface and when fully grown will turn yellow, sweet taste and a great aroma (Mitchell, 2007). Galia melon was a type of F_1 hybrid melon breeding from a cross between the green-flesh melon cultivar 'Ha-Ogen' and the netted-rind melon cultivar 'Krimka', which developed by the melon breeder Dr. Zvi Karchi and released in 1973 (Karchi, 2000).melon

2.2 The botanical characteristics of melon

Melon was a vine climbing through a branch. The trunk was round with thorns resembling a hairy, clinging to a single leaf, alternately petioles hollow. The base of the concave leaf base. The jagged edges were wavy, the surface was rough, young leaves had hair at the edge of the leaf and under the leaves. There were both staminate flowers, pistillate flowers and complete flowers on the same plant. All cultivars had color, peel and pulp color vary according to varieties. The pulp may be yellow, yellowish green color and orange color. The seeds were brownish yellow color (Pooma, 2014). Galia melon had scientific name *Cucumis melo* L. var. *reticulatus* Ser. Also known as musk melon, netted melon, or nutmeg melon. The skin was straw-colored with a tightly woven mesh pattern. The fruit was medium in size, fragrant, fine melon, orange, sweet (Chimongkon, 1985).

2.3 The environment that is suitable for melon growth

Melon grows well at temperatures between 25-35 °C. The suitable season was the end of the rainy season or the beginning of winter. If planting melons were cold climates, such as night when the lower temperature, it will halt the growth from the seedling stage effect the growth and harvesting slow down. However, if the weather gets cold suddenly, the melon will have only staminal flowers, and will not have hermaphrodite or festinate flowers, Hermaphrodite flowers or festinate flowers will appear when the weather was warmer, or these flowers may be found on the higher segments of the plant. If planted in hot weather, it will often be found that the festinate flowers are not growing, or are having problems with breeding, the flowers will be yellow and fall. An environment in which the plant receives insufficient sunlight limiting the production of plant food. Relative humidity was also important for plant growth, low relative humidity in the air, causes high dehydration of the plants, as a result, the plants can absorb more nutrients through their roots, which is also suitable for, pollination, fruiting, and growth (Tira-umphon, 2016).

2.4 Cross breeding plant improvement and Inbred line extraction

Plant breeders must plan research with the objectives of breeding because it will make the breeding of plants successful. Then study the relevant information such as the nature of the plant to be breed, propagation mating, characteristics genetic diversity and relevant genetic information such as qualitative or quantitative characteristics, heterosis and heritability. This information will be helpful in making informed plant breeding decisions and effective to achieve the objectives (Kankaew, 2011). The breeding for cross-pollination crop, found that each plant has heterozygous of characteristics. When many plants were combined in cross-plant populations, this causes the population to be given a qualification as a heterogeneous population because of hybrid lines had good characteristics. This was because their genes had the over dominant characteristics or epistasis. At the same time as having genetic diversity, allowing the plants to be able to adapt to the changing environment. In cross-pollination crop, the resulting hybrid had different from the parental, which is the first selection in the hybrid, believing that it will achieve good characteristics because it was a self-pollination crop, so in the later stages of cross breeding the plant will become homozygous (Chaitiang, n.d.). The production of inbred line that every plant has the same genotype. In the self-pollination crop, which had homozygous genotype and the same, every seed. Therefore, it was automatically inbred line, but in cross-pollination crop such as melon was each plant of each seed was heterozygous when constantly self-pollinated weakens the plant. The inbred line selection method, adapted from Johannsen method, used to selected *Phaseolus vulgaris*, selecting from many plants, and then plant-to-row or head-to-row, the key was that the selected plants must had different genotypes, and genotype was homozygous. The inbred line selection can be done in several ways, for example inbred selection. In cross-pollination crop were produced by self-pollination. Then selected was to produce hybrids next (Laosuwan, 2003). When inbred lines were obtained and then tested for the combining ability of the inbred lines by diallel cross method to find a suitable breed for use as a parent in further breeding program, then to produce F_1 hybrid seeds. (The Office of Agricultural Research and Extension Maejo University, 2016).

Khanobdee (2014) Inbred line selection of cucumber gherkin varieties for mildew resistance using 3 methods such as inbred line selection, pedigree selection, and back cross selection, found that the average genetic regression of mildew levels equal to 29.4% -26.4% and -1.5%.

Pidkwamlub (2014) Inbred line selection in the hybrid glutinous rice corn improvement project and genetic testing, which selecting population by S1 selection: (1) half - sib (HS), (2) full - sib (FS), and (3) S1- progeny test (S1); this method was able to select S2 population with good agricultural potential.

2.5 Gene action

The characteristics of living organisms can be divided into 2 basic genetics.

1. Qualitative characteristics are characterized and controlled by a little pair of genes, each pair expresses clearly, distribution of genes in various generations, clearly organized into groups, which the environment rarely influences such as appearance of pulp color, peel color, and disease resistance etc.

2. Quantitative characteristics are characterized and controlled by many genes, each of the genes showed the genotype were non-clearly, the distribution of genes in various generations cannot be clearly classified, the environment has a lot of influence on expression such as weight, sweetness, and pulp thickness of fruit, etc. (Boonhong, 2005: References in Kachen, 2008). The gene action can be divided into 2 groups as follows: **1) The synergies of genes in different positions** are the sum of the results, instead of the sum of the same genes, the sum of the different genes that control the same nature. Many genes that control the same nature in a positive way are called multiple factors, which each gene works independently. **2) The synergies of the genes within the same locus include.**

Additive gene action was cumulative positive gene, it's causing the heterosis of hybrids, this allows plant breeders to select outstanding species from an early generation, allowing progress in selection and genetics to be in equilibrium or fixed, quickly. Therefore, this was suitable for selecting plants, that self-pollination, that need to be inbred line, which will have the stability of the genes in different positions from one generation to another and showing stable results in various environments as well (Kankaew, 2011).

Non-additive gene action was an expression of uninterrupted genes like the accumulation of positive gene expression, the expression of hybrid was clearly distinguished from the parents especially in early generations, which was difficult for prediction of progress from the selected results, since in later generations these distinctive characteristics will disappear during the generation that has been selected such as the selection to be an early variety. However, early variety characteristic will be expressive in F_1 hybrid (Kankaew, 2011). When selected in a later generation, early variety characteristic will gradually disappear, eventually becoming late variety characteristics instead. Non-additive gene action, divided into 3 types: complete dominance, incomplete dominance and over dominant (Brown, 2008).

Hughes (1948) Reported that in Honeydew and Smith's Perfect line, there are w genes that control the white peel, which is recessive characteristics to the dark green of peel color. Two genes that control the nets on the peel are the *N gene* that controls nets and *gene n* controlling smooth peel effect (Ramaswamy, 1997).

Hughes (1948) were quoted in Kachane (2008) Reported that the genes control the green pulp being suppressed by the orange pulp genes control in Honeydew and Smith's Perfect.

Lumsden (1914) were referred to in Nonnecke (1922) Described breeding between muskmelon, to studies the expression of the F2 hybrids, found that yellow peel color which controlled by dominant genes, green color was controlled by recessive genes, rough surface with reticular nets was controlled by dominant genes, smooth surface without nets was controlled by recessive genes, round shape was controlled by dominant genes, oval shape was controlled by recessive genes, large size of fruit was controlled by dominant genes, small size of fruit was controlled by recessive genes, large size of seed was controlled by dominant genes, and small size of seed was controlled by recessive genes.

Pornsuriya (2012) Estimate of gene action on fruit characters of 2 Thai melon lines. Found that the additive gene effects were significant controlling days to male anthesis, days to first harvest and fruit cavity width, whereas dominance gene effects were more important than additive gene effects in controlling days to male anthesis, days to first harvest, fruit length, fruit cavity length and fruit flesh thickness. Non-allelic gene interactions were significant in fruit width, fruit length, fruit cavity length and fruit pulp thickness, and dominance x dominance type of gene action was most important in controlling these characteristics.

2.6 Combining ability test

The combining ability test was selection population step or inbred line selection of many lines with many inbred lines. Once a hybrid is made, may be not matched to the breeding objectives (Patthum, 2001). The final breeding objective, to create hybrid in cross-pollinated plants. To produce hybrids, which may get a perfectly good, inbred line can produce to hybrids or totally fail. This depends on the choice of parent lines and breeding method. Genetic differences are observed, which results in high-yield hybrids with high variability in the genetic characteristics of their hybrid. Conversely, if the parents have similar genetic characteristics, the hybrids will be like their parents, hybrid in later generations will have low genetic variability, and there will be no progress in selecting new lines (Laosuwan, 2003). Therefore, in this experiment, the selected strains were used to test the potential of line, namely the combining ability test, heterosis and characteristics correlation. The combining ability test of inbred lines had 2 types. **1) General Combining Ability (GCA)** means the ability of a particular lines when cross with many other lines and then to give an average of high hybrids. And **2) Specific Combining Ability (SCA)** means the ability of a particular line when cross with other lines to give a high hybrid, it is the unique capability of those pairs: GCA is variance is the result of additive genes. There are 3 methods for combining ability test performance of a widely used lines, each method is effective, and limitations are different. The selection of methods to suit the conditions of the work will help to save labor, budget and time and increase the efficiency of breeding as well as the following 1) topcross 2) diallel cross 3) factorial cross (Funpeng, 2010).

Griffing (1956) There were four different methods for diallel design based on whether the parents, their reciprocal F_1 hybrid or both, were included in the evaluation with the F_1 hybrid: Method I or Full Diallel Design: The method I or full diallel design consisted by parents, one set of F_1 hybrid and reciprocal F_1 hybrid. The system gives n2 genotypes. Method II: This method encompasses parents and one set of F_1 hybrid without reciprocals F_1 hybrid. This design gives n (n + 1)/2 genotypes. Method III: Here, one set of F_1 hybrid and the reciprocals are investigated. This design provides the equation a = n (n - 1) different number of genotypes. Method IV: Here, it only includes F_1 hybrid. This design provides the equation a = n (n - 1)/2 different number of genotypes.

Kamer (2015) Studies was the hybrid vigor, heritability, inbreeding depression, number of gene pairs were valued for fruit characters and yield in melon. They used half-diallel mating system to obtain 10 hybrids combinations. The results were revealed the hybrid were significant with positive heterosis and heterobelosis for all character.

Khanobdee (2016) Studies was the improvement of long fruit hybrid cucumber (*Cucumis sativus* L.) for resistance to downy mildew on increasing productivity and reducing the cost of chemicals used two methods of combined ability test follow Griffing's method I. From the diallel cross showed moderate resistance to downy mildew, stable stability with a high negative SCA of downy mildew resistance and positive SCA of fruit length.

Pornsuriya (2016) Studies was to estimate heterosis for fruit characters and yield in the inter-varietal hybrids of oriental sweet melon. They were used a half-diallel cross. The results showed that significant variety effect was observed for all characters. Heterosis effect was significant for fruit weight, fruit width, fruit shape index and yield. Overall heterosis partitioned into components showed that average heterosis and variety heterosis were significant for fruit width and fruit shape index. Specific heterosis was significant for fruit weight, fruit width, fruit shape index and yield.

2.7 Heterosis of characteristics

Heterosis of characteristics means the phenomenon that hybrids are strong, growing, giving good yield, resistant to diseases and insects, drought resistant, and have other characteristics better or higher than that of the parent lines. Heterosis of characteristics may be caused by the plant being in a heterozygous, therefore, high heterosis are found F_1 hybrids of hybrids between cross-pollination crops. Heterosis of hybrids in the same plant may had different levels if different varieties were line. Moreover, even for the same hybrids the heterosis rate in different generations will be different. The heterosis of hybrids may be measured in two ways: 1) Measured by comparing with the average of parents is a measure of the percentage of hybrid improvement against the average of their parents, this method of measurement is called outstanding above average of parents or heterosis, this method of measurement shows that such characteristics had the expression of dominant genes and 2) Measured by comparing with the average of the better parent lines, this method of measurement is a measure of the properties by using the average of the hybrids to compare with the parents that give good characteristics, this method of measurement is called heterobeltiosis (Laosuwan, 2003).

Iathet (2006) Studies the heterosis between 2 varieties of cantaloupe, found that yield per plant gave a heterosis value of 12.71%, and total yield per plant gave a heterosis value of 8.20%. Showed the hybrid between 2 varieties of cantaloupe gave yield per plant had high heterobeltiosis, and the total yield per plant was high heterosis.

Kamer (2015) Studies were the hybrid vigor, heritability, inbreeding depression, number of gene pairs were valued for fruit characters and yield in melon. They used half-diallel mating system to obtain 10 hybrids combinations. The results revealed the hybrid were significant with positive heterosis and heterobelosis for all character. Most the hybrids showed high broad sense heritability for the traits of plant length, number of branches per plant, flowering date, maturity date, fruit pulp thickness, peel color, sweetness, moisture content and vitamin C. But the traits of plant length and fruit pulp thickness showed high narrow sense heritability. Most of the hybrids exhibited inbreeding depression for the characters of plant length, maturity date, sweetness, moisture, and vitamin C.

Pornsuriya (2016) Studies was to estimate heterosis for fruit characters and yield in the inter-varietal hybrids of oriental sweet melon. The results showed that significant variety effect was observed for all characters. Heterosis effect was significant for fruit weight, fruit width, fruit shape index and yield. Overall heterosis partitioned into components showed that average heterosis and variety heterosis were significant for fruit width and fruit shape index. Specific heterosis was significant for fruit weight, fruit width, fruit shape index and yield.

Pornsuriya (2018) Studies was the yield performance and heterosis for yield of crosses between Thai melon lines and cantaloupe testers was determined involving 4 Thai melon lines (L1, L2, L3 and L4) and 3 cantaloupe testers (cantaloupe populations: T1, T2 and T3). The results revealed that parents and crosses were significantly different in yield. The hybrid gave the highest yield, and significantly positive heterosis and significantly positive heterobeltiosis.

2.8 Correlation

Correlation refers to various aspects of related plants, relationships may be positive or negative. The relationships may increase or decrease together, or one increases but another reduces. The relationships may be caused by characteristics controlled by the same gene, or the development of a particular characteristic depends on the development of another characteristic. The relationship between characteristics may be used to assist in plant breeding. Correlation of plants, which can be divided into 3 types: phenotypic correlation, genetic correlation, and environmental correlation (Laosuwan, 2003).

Iathet (2006) Studies was correlations of fruit characters and yield in of Thai melon. They are with two inbred lines (RM1 and LM2) of slicing melon. The results revealed the fruit width correlated negatively with fruit length and the result shape index. Fruit shape and fruit size did not correlate with fruit number per plant and yield. While the number of fruits per plant had a high positive correlation with the yield per plant. Showed that correlations between traits can be used to help improve plant varieties. Indirect selection may be conducted in multiple characteristics or in multiple characteristics at the same time. Using data from correlated studies.

Ibrahim (2013) Studies were genotypic correlation and path analyses were carried out for growth, yield, and fruit quality traits in 13 sweet melon genotypes collected from different places in Egypt. They were studying the correlation at under irrigated conditions. The results revealed the total yield per plant was positively and significantly correlated with fruit weight, fruit pulp thickness and fruit length. Positive direct effects were exhibited for fruit weight, number of fruits per plant and stem length on total yield per plant, while maximum positive indirect effects on total yield per plant were exhibited by fruit length and fruit pulp thickness through fruit weight.

CHAPTER III

RESEARCH METHODOLOGY

The experiment was conducted at Suranaree University of Technology Farm, Suranaree University of Technology, Nakhon Ratchasima. The inbred line selection from F_3 seeds of original research (Tira-umphon, 2017). The experiment detail as follow:

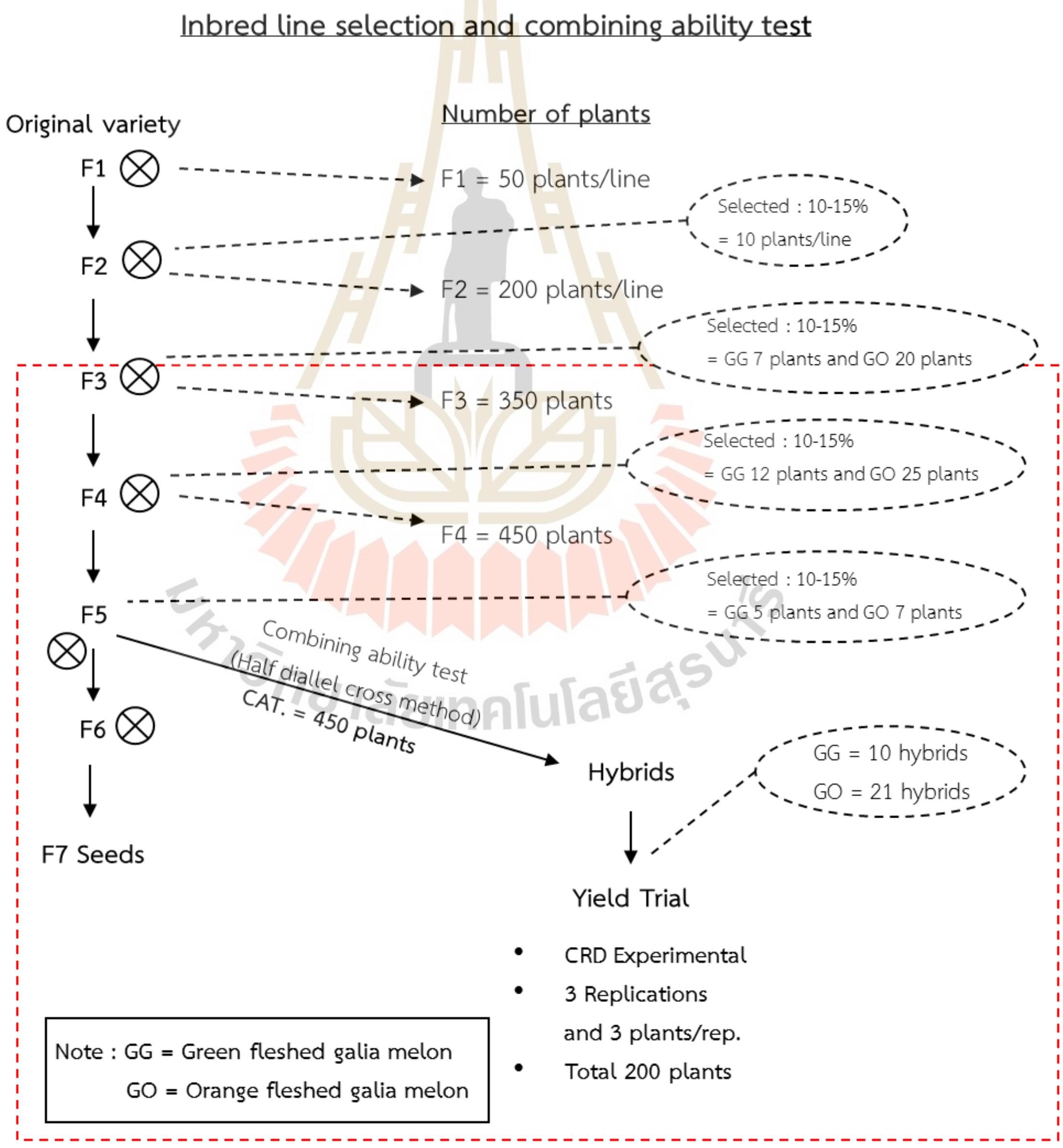

Figure 3.1 The plan of experimental in research.

The original research

F_1 hybrids (Original variety): The original variety from "Rattanasook farm" which was green-fleshed galia melon and orange-fleshed galia melon. The plants were planted in 50 plants per varieties all total 100 plants. Then, self-pollination, and 10-15% of selected were 10 plants per lines which to seeds and continue planting in F_2 plants.

F_2 plants: From the previous selection of 2 lines. The plants were planted in 200 plants per lines all total 400 plants. Then, self-pollination, and 10-15% of selected were 7 plants (lines) in green-fleshed galia melon, and 20 plants (lines) in orange-fleshed galia melon. Which to seeds and continue planting in F_3 plants.

3.1 Thesis experimental

The thesis was experimental all 3 parts as follow:

3.1.1 The inbred line selection from F_3 plants to F_6 plants

F_3 plants: From the previous selection of 2 lines. The plants were planted in 15 plants per line of each lines all total 405 plants. Then, self-pollination, and 10-15% of selected were 12 plants (lines) in green-fleshed galia melon, and 25 plants (lines) in orange-fleshed galia melon. Which to seeds and continue planting in F_4 plants.

F_4 plants: From the previous selection of 2 lines. The plants were planted in 12 plants per line of each lines all total 444 plants. Then, self-pollination, and 10-15% of selected were 5 inbred lines in green-fleshed galia melon, and 7 inbred lines in orange-fleshed galia melon. Which to seeds and continue planting in F_5 plants and combining ability test.

F_5 plants: From the previous selection of 2 lines. The plants were planted in 12 plants per line of each lines all total 144 plants. Then, self-pollinated which to seeds and continue planting in F_6 plants.

F_6 plants: The plants were planted in 9 plants per inbred line with 3 replications and 3 plants per replications, green-fleshed galia melon were planted 45 plants, orange-fleshed galia melon were planted 63 plants, all total 108 plants. Then, self-pollination which the test plants to find general combining ability value of parent lines and last output were F_7 seeds.

3.1.2 The combining ability test

The combining ability test was using half diallel cross method, followed Griffing's Method 2 Model 1 (Griffing, 1956), which seeds of F_5 seeds in selected (Table 3.1). For green-fleshed galia melon gave 10 hybrids, and orange-fleshed galia melon gave 21 hybrids. The experiment plan uses the completely randomized design (CRD). There were 3 replications and 3 plants per replication, all total 279 plants.

Table 3.1 The pedigree of the inbred lines of green-fleshed galia melon (A) and orange-fleshed galia melon (B).

Lines	Pedigree	Code
Green-fleshed galia melon (GG)	GG-01-08-02-05-27	A1
	GG-03-08-02-01-29	A2
	GG-03-08-02-12-13	A3
	GG-03-08-05-08-28	A4
	GG-07-01-09-11-28	A5
Orange-fleshed galia melon (GO)	GO-02-17-11-06-35	B1
	GO-03-23-10-11-35	B2
	GO-03-27-10-08-36	B3
	GO-04-16-06-01-40	B4
	GO-04-18-06-05-37	B6
	GO-04-21-05-06-xx	B7
	GO-05-07-14-01-36	B8

3.1.3 Test planting (yield trial)

The yield trial of hybrids all lines of fruit and yield component characteristics and planted for comparison with parent lines. The hybrids of green-fleshed galia melon, 10 hybrids and 5 parent lines, all total 15 entries (Table 3.2). The hybrids of orange-fleshed galia melon, 21 hybrids and 7 parent lines, all total 28 entries (Table 3.3). The experiment plan uses the completely randomized design (CRD). There were 3 replications and 3 plants per replication, all total 387 plants.

Table 3.2 The 5 parentals and 10 hybrids of green-fleshed galia melon.

Inbred lines	A1	A2	A3	A4	A5
A1	X	X	X	X	X
A2		X	X	X	X
A3			X	X	X
A4				X	X
A5					X

Table 3.3 The 7 parentals and 21 hybrids of orange-fleshed galia melon.

Inbred lines	B1	B2	B3	B4	B6	B7	B8
B1	X	X	X	X	X	X	X
B2		X	X	X	X	X	X
B3			X	X	X	X	X
B4				X	X	X	X
B6					X	X	X
B7						X	X
B8							X

3.2 Planting methods

The seeding using peat moss in the seed tray. When they are 12 days old of plants move the seedlings into green house and transfer them into 7x14 inch planting bags which have planting materials consisting of SUT planting soil. Place the planting bags in a double zigzag row, making the distance between the plants and between the rows 50x 50 centimeters. Gave chemical fertilizer formulas 16-16-16, 13-13-21 and 0-0-60 and provide water through a drip system twice a day. Make the plants climb up and pick the 1st to 8th lateral buds out, begin raising from the 9th lateral buds. Before pollination, prepare staminate flowers and pistillate flowers by choosing the flowers 1 day before the flowers bloom, use wire to strap staminate flowers and pistillate flowers close together to prevent crossing from other lines. The 1 week after fruiting, choose 1 fruit per plant, when the fruit grows use a rope to help support the weight of the fruit. Pick treetops out when they have 25 large leaves, trim leaves from the 1st to 4th wood joints. Get rid of pests and diseases according to the epidemic. After that, select good vigor plants according to the need, to inbred line selection up to F_6 plants.

3.3 Harvesting

Harvest the melons, after 45 days of self-pollination, by observing the characteristics of slip of the fruit, fruit appraisal, nets, mesh, volume, and if the melon has a net. For melons that have no polarity of the fruit, by observing if meshes are fully formed around fruits, observing the dark color of the fruit and if the smell of the fruit has increased (Sripongprapai, 2014).

3.4 Data collection

The data recording per plant is as follows:

1. Fruit peel color and fruit pulp color measure by Chromameter CIELAB system, measure peel, every treatment, by measuring the average of 3 points, head of the fruit, middle of the fruit and bottom of the fruit.

2. The net pattern will be scored by the net pattern of the fruits as follows:

   5 = With had net 76-100%

   4 = With had net 51-75%

   3 = With had net 26-50%

   2 = With had net 5-25%

   1 = With don't have net or with had net 0 or < 5%

3. Slip; with slip or without slip.

4. Fruit weigh, record data when harvesting melon, weighing fruits by using scales in kilograms.

5. Fruit width, records data when harvesting products, by vernier caliper in centimeters.

6. Fruit length, records data when harvesting products, by vernier caliper in centimeters.

7. Fruit cavity width, records data when harvesting products, by vernier caliper in centimeters.

8. Fruit cavity length, records data when harvesting products, by vernier caliper in centimeters.

9. Fruit pulp thickness, records data when harvesting products, by vernier caliper in centimeters.

10. Fruit peel thickness, records data when harvesting products, by vernier caliper in centimeters.

11. Sweetness, records data when harvesting products, by squeezing the juice from the melon to measure the Brix value by hand refractometer, measure in percentage units (Cantwell, 2011).

12. Firmness, records data when harvesting products by the fruit firmness meter, units in Newton (N).

13. Percent of pulp, the measure as follow:

$$\% \text{ of pulp} = \frac{2\times\text{Fruit pulp thickness}}{\text{Fruit width}}\times 100$$

3.5 Selection criteria

3.5.1 Evaluation of peel color and pulp color.

Lines	Fruit pulp color	Type	Selected
Green-fleshed galia melon	White-Green, or White	1	
	Light Green	2	✓
	Dark Green		
Orange-fleshed galia melon	White-Orange, or White	1	
	Light orange	2	✓
	Dark Orange		

Remark: The selection was type 2 was chosen for F_1 hybrid to F_3 hybrid.

Figure 3.2 The pulp color and peel color of galia melon.

3.5.2 Evaluation of netting density.

Phonotype	Score	Selected
With had net 76-100%	5	✓
With had net 51-75%	4	✓
With had net 26-50%	3	
With had net 5-25%	2	
With don’t have net or with had net low than 5-25%	1	

Remark: The netting was at score 2 or more was chosen for F_1 hybrid to F_3 hybrid.

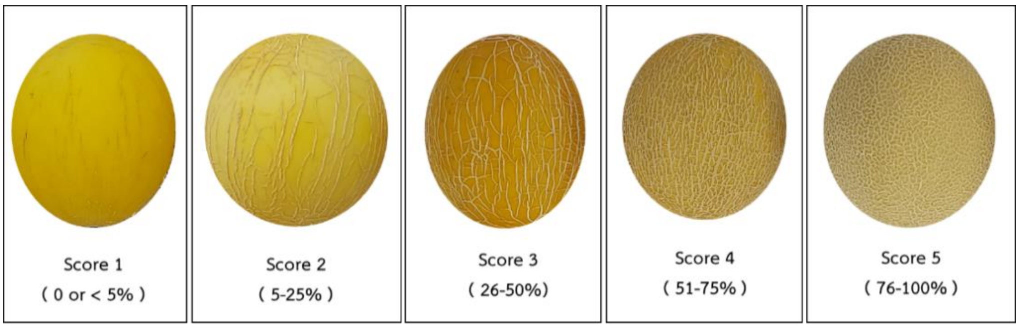

Figure 3.3 Rating level of the nets of galia melon.

3.5.3 Evaluation of slip type.

Phonotype	Type	Selected
With vertical and horizontal for slip	4	✓
With horizontal for slip	3	✓
With vertical for slip	2	✓
Non-slip	1	

Remark: The slip was at Type 2 or more was chosen for F_1 hybrid to F_3 hybrid.

Figure 3.4 The type of slip for galia melon.

5.5.4 Evaluation of fruit weight.

Weight range (kg)	Selected
1.20 – 1.49	✓
0.90 – 1.19	
0.60 – 0.89	
0.30 – 0.59	
0.10 – 0.29	

Remark: Fruit weight was at least 12 kg. was chosen for F_4 hybrid selection.

3.5.5 Evaluation of sweetness.

Sweetness (%Brix)	Selected
12.0 up	✓
10.0 – 11.9	
8.0 – 9.9	
6.0 – 7.9	
4.0 – 5.9	

Remark: The fruit was at least 12%Brix was used for further F_4 hybrid selection.

For the case of the selected does not meet the criteria set forth in F_3 hybrid with the selection criteria from the pulp color, net, and slip. If the selection is not defined will bias to be net primary. For the F_4 hybrid onwards that the case of the selected does not meet the criteria, will bias to be sweetness primary.

3.6 Statistical data analysis

3.6.1. Statistical variability analysis

The variance was analyzed according to the CRD experimental plan, and the mean was compared by Duncan's New Multiple Range Test (DMRT) at the significance level. 0.05 and analyze the relationship between yield composition and yield of melon. using statistical program SPSS for windows version 14.0.

3.6.2 Combining ability analysis

Analysis of variance According to the CRD experimental plan to find differences between the experiments in the way the data is recorded If any differences are found between the experiments Therefore, the performance of the combination of Griffing (1956) Method 2 with mathematical model was analyzed as follows:

$$x_{ij} = \mu + g_i + g_j + s_{ij} + \frac{1}{b}\sum_k e_{ijk}$$

where: $(i = j = 1 \ldots . p; k= 1 \ldots . b)$

where, μ = the population mean.

g_i = the general combining ability effect of the ith parent.

g_j = the general combining ability effect of the jth parent.

s_{ij} = the specific combining ability effect of the cross between i^{th} and j^{th} parents such that $s_{lj} = s_{ji}$ and

e_{ijk} = the environmental effect associated with ij k^{th} observation.

Analysis of variance for method 2 giving expectations of mean squares of model 1 (Griffing, 1956).

source	df	SS	MS	Expectation of Mean Squares
GCA	p-1	SS_g	MS_g	$\sigma^2+(p+2)[\frac{1}{p-1}]\sum_{gi} 2$
SCA	p(p-1)/2	SS_s	MS_s	$\sigma^2 + \frac{2}{p(p-1)}\sum_i \sum_j sij^2$
Error	m	SS_e	$MS_{e'}$	σ^2

Note: $MS_{e'}$ = Me/rc (where M_e was the error MS of CRD ANOVA, r was the number of iterations and c was the number of plants stored in each iteration).

$$SS_g = \frac{1}{p+2}\{\sum(x_{i.} + x_{jj})^2 \simeq \frac{4}{p} x\ldots^2\}$$

$$SS_s = \sum\sum x_{ij}{}^2 - \frac{1}{p+2}\sum(x_{i.} + x_{jj})^2 + \frac{1}{(p+1)(p+2)} X\ldots^2$$

m = df of error from statistical analysis.

p = Total number of parent line used in cross.

$x_{i.}$ = Sum of the mean of all hybrid's pairs obtained by interbreeding of lines i and the rest of the species = $x_{i1} + x_{i2} + x_{i3} + \ldots\ldots + x_{in}$

$x_{j.}$ = Sum of the mean of all hybrid's pairs obtained from crossing between line j and the rest of the line = $x_{j1} + x_{j2} + x_{j3} + \ldots\ldots + x_{jn}$

x_{ij} = Mean of hybrids resulting from self-pollinated of line i

x_{jj} = Mean of hybrids resulting from self-pollinated of line j

$x\ldots$ = The sum of the mean of all hybrids pairs obtained by interbreeding i or j and the rest of the lines plus the mean of hybrids resulting from i or j self-pollination.

For testing the differences due to combined ability, do the following:

General combining ability test (GCA) $F_{[(p-1), m]}$ = $MS_g/MS_{e'}$

Specific combining ability test (SCA) $F_{[p(p-1)/2, m]}$ = $MS_g/MS_{e'}$

For calculating the effect of GCA in each parent or the effect of SCA in each pair, it can be done as follows:

$$g_i = \frac{1}{p+2}[x_{i.} + x_{ii} - \frac{2}{p} x\ldots]$$

$$s_{ij} = x_{ij} - \frac{1}{p+2}[x_i + x_{ij} + x_j + x_{jj}] + \frac{2}{(p+1)(p+2)} x\ldots$$

3.6.3 The study heterosis of F_1 hybrid

Measured by comparison with the mean of the parent lines.

$$\text{Heterosis (\%)} = \frac{\overline{F1}-\overline{MP}}{\overline{MP}} \times 100$$

where, F_1 = mean of the hybrids.

MP = mean of the parent lines.

Testing for significance by comparing the values of t-statistics as follow:

$$t_{(MP)} = \frac{\overline{F1}-\overline{MP}}{\overline{S1}}$$

$$S1 = \sqrt{\frac{(n_{P1}-1)MS_{P1}+(n_{P2}-1)MS_{P2}}{(n_{P1}+n_{P2})[(n_{P1}-1)+(n_{P2}-1)}} + \sqrt{\frac{MS_{F1}}{n_{F1}}}$$

Where:

MS_{P1} = the mean square of the parent.

MS_{P2} = the mean square of the parent.

MS_{F1} = the mean square of the F_1 hybrids.

n = the number of trees in that generation.

Measured by comparison with the mean of the better parent lines.

$$\text{Heterobeltiosis (\%)} = \frac{\overline{F1}-\overline{HP}}{\overline{HP}} \times 100$$

where, F_1 = mean of the hybrids.

HP = mean of the better parent lines.

Testing for significance by comparing the values of t-statistics as follows:

$$t_{(HP)} = \frac{\overline{F1}-\overline{HP}}{\overline{S2}}$$

$$S2 = \sqrt{\frac{MS_{F1}}{n_{F1}}} + \sqrt{\frac{MS_{HP}}{n_{HP}}}$$

Where:

MS_{F1} = the mean square of the F_1 hybrids.

MS_{HP} = the mean square of the better parent

n = the number of plants in that generation.

3.6.4 Correlation Coefficient Analysis

Use data from the F_5 hybrids to analyze phenotypic correlation, to study phenotypic correlation according to the method provided by Briggs and Knowles (1967) as follow:

$$r = \sqrt{\frac{\sum XiYi - \frac{(\sum Xi)(\sum Yi)}{n}}{\left[\sum X_i^2 - \frac{(\sum X_i^2)}{n}\right][\left[\sum Y_i^2 - \frac{(\sum Y_i^2)}{n}\right]}}$$

Where: X_i = the observed value X at i

Y_i = the observed value Y at i

when i = 1, 2, 3,.. n (n = Amount of the observed value)

CHAPTER IV
RESULTS

The study inbred line selection of parental, combining ability test of melon lines, heterosis of F_1 hybrid and correlation between fruit components and yield characteristics. For galia melon were divides 2 cultivars, green-fleshed galia melon (GG) and orange-fleshed galia melon (GO), which the selection inbred lines until F_5 hybrid, the results of selected were 5 inbreed lines of green-fleshed galia melons (A1, A2, A3, A4, and A5) and 7 inbred lines of orange-fleshed galia melons (B1, B2, B3, B4, B6, B7). The details of genotype are as follows (Table 4.1 and Figure 4.1).

Table 4.1 Descriptions of the melon parental genotypes used in the present research.

Pedigree	Code	Shape	Peel color	Pulp color	Mesh	Slip
GG-01-08-02-05-27	A1	Oval	Light yellow	GW	76-100%	Slip
GG-03-08-02-01-29	A2	Oval	Light yellow	G	76-100%	Slip
GG-03-08-02-12-13	A3	Round	Dark yellow	G	76-100%	Slip
GG-03-08-05-08-28	A4	Round	Dark yellow	GW	76-100%	Slip
GG-07-01-09-11-28	A5	Round	Light yellow	G	76-100%	Slip
GO-02-17-11-06-35	B1	Round	Dark yellow	OR	26-50%	Slip
GO-03-23-10-11-35	B2	Oval	Light yellow	OR	76-100%	Slip
GO-03-27-10-08-36	B3	Round	Green, yellow	OR	76-100%	Slip
GO-04-16-06-01-40	B4	Round	Dark yellow	G	76-100%	Slip
GO-04-18-06-05-37	B6	Oval	Dark yellow	G	76-100%	Slip
GO-04-21-05-06-xx	B7	Round	Light yellow	G	76-100%	Slip
GO-05-07-14-01-36	B8	Round	Dark yellow	W	26-50%	Slip

Note: GW = green-white, G = green, OR = orange and W = white

The study selection of parental found that 5 parentals of green-fleshed galia melon and orange-fleshed galia melon, with different genotypes as follow:

Green-fleshed galia melon (GG): A1 line has oval shape, light yellow color of peel, green-white color of pulp, 76-100% of mesh, and slip. A2 line has oval shape, light yellow color of peel, green color of pulp, 76-100% of mesh, and slip. A3 line has round shape, dark yellow color of peel, green-white color of pulp, 76-100% of mesh, and slip. A4 line has round shape, dark yellow color of peel, green-white color of pulp, 76-100% of mesh, and slip. A5 line has round shape, light yellow color of peel, green color of pulp, 76-100% of mesh, and slip.

Orange-fleshed galia melon (GO): B1 line has round shape, dark yellow color of peel, orange color of pulp, 26-50% of mesh, and slip. B2 line has oval shape, light yellow color of peel, orange color of pulp, 76-100% of mesh, and slip. B3 line has round shape, green-yellow color of peel, orange color of pulp, 76-100% of mesh, and slip. B4 line has round shape, dark yellow color of peel, green color of pulp, 76-100% of mesh, and slip. B6 line has oval shape, dark yellow color of peel, green color of pulp, 76-100% of mesh, and slip. B7 line has round shape, light yellow color of peel, green color of pulp, 76-100% of mesh, and slip. B8 line has round shape, dark yellow color of peel, white color of pulp, 26-50% of mesh, and slip.

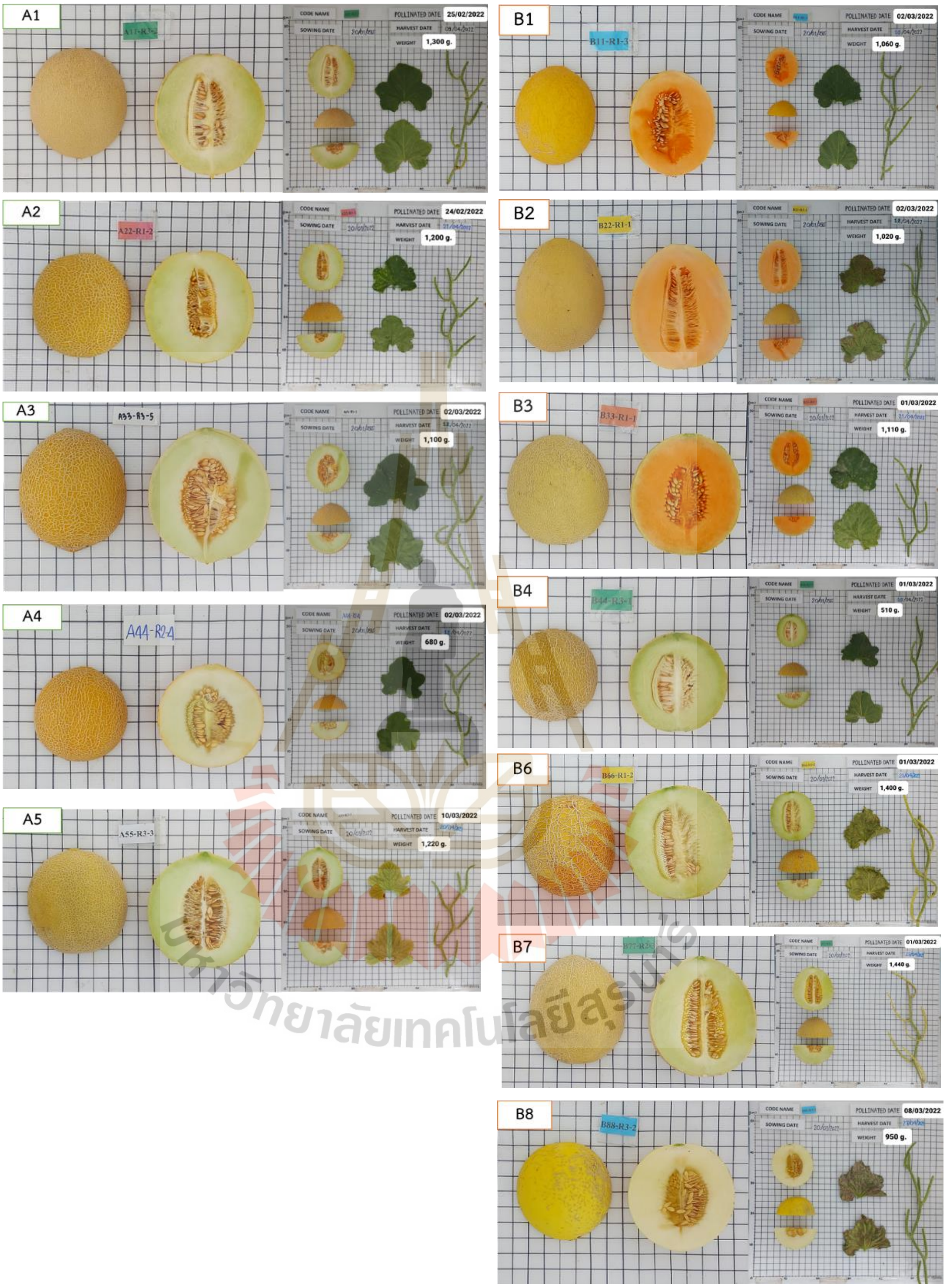

Figure 4.1 The parental of green-fleshed galia melon (A1, A2, A3, A4, A5) and orange-fleshed galia melon (B1, B2, B3, B4, B6, B7, B8).

4.1 Green-fleshed galia melons

4.1.1 Analysis of variance

The variance analysis of 10 recorded characteristics were fruit weight, fruit width, fruit length, fruit cavity width, fruit cavity length, fruit pulp thickness, fruit peel thickness, sweetness, firmness, and percentage of fruit pulp, it was found that the characteristics of fruit weight, fruit width, fruit length, fruit cavity length and fruit pulp thickness showed a statistically significant difference due to genotype ($P<0.01$). For the comparison among the parent lines and for the comparison among the hybrids, it was found that the characteristics of fruit weight, fruit width, fruit length, fruit cavity length, fruit cavity length and fruit pulp thickness. There was a statistically significant difference. Class comparisons between parent lines and hybrids, it was found that the fruit weight, fruit width, fruit length, fruit cavity length, fruit pulp thickness and sweetness were significantly different from each other (Table 4.2). The variance analysis of mean of 5 parent lines and 10 hybrids, the detail follow (Table 4.3 and Table 4.4).

Fruit weight: The variance analysis of mean for 5 parent lines, found that the lines A5, A2 and A1 had high average and statistically significant (1.22, 1.08 and 1.05 kg, respectively). For the variance analysis of mean for 10 hybrids, found that the hybrids A12, A14, A15 and A25 had high average and statistically significant (1.53, 1.43, 1.54 and 1.48 kg, respectively).

Fruit width: The variance analysis of mean for 5 parent lines, found that the lines A5 and A2 had high average and statistically significant (13.00 and 12.33 cm, respectively). For the variance analysis of mean for 10 hybrids, found that the hybrids A12 and A15 had high average and statistically significant (13.73 and 13.72 cm, respectively).

Fruit length: The variance analysis of mean for 5 parent lines, found that the lines A5, A1 and A2 had high average and statistically significant (14.40, 14.12 and 13.63 cm, respectively). For the variance analysis of mean for 10 hybrids, found that the hybrids A15 and A25 had high average and statistically significant (16.07 and 16.17 cm, respectively).

Fruit cavity width: The variance analysis of mean for 5 parent lines, found that the line A2 has low average and statistically significant (4.28 cm). For the variance analysis of mean for 10 hybrids, found that all hybrids had statistically nonsignificant.

Fruit cavity length: The variance analysis of mean for 5 parent lines, found that the lines A3 and A2 had low average and statistically significant (6.77 and 6.95 cm, respectively). For the variance analysis of mean for 10 hybrids, found that the hybrids A13, A34, A35 and A45 had low average and statistically significant (7.43, 7.25, 7.68 and 7.62 cm, respectively).

Fruit pulp thickness: The variance analysis of mean for 5 parent lines, found that the line A2 has high average and statistically significant (3.03 cm). For the variance analysis of mean for 10 hybrids, found that the hybrids A12 has high average and statistically significant (3.45 cm).

Fruit peel thickness: The variance analysis of mean for 5 parent lines, found all lines had statistically nonsignificant. For the variance analysis of mean for 10 hybrids, found that all hybrids had statistically nonsignificant.

TSS: The variance analysis of mean for 5 parent lines, found all lines had statistically nonsignificant. For the variance analysis of mean for 10 hybrids, found that the hybrids A23 and A35 had high average and statistically significant (14.63 and 14.70 brix).

Firmness: The variance analysis of mean for 5 parent lines, found all lines had statistically nonsignificant. For the variance analysis of mean for 10 hybrids, found that all hybrids had statistically nonsignificant.

Percentage of fruit pulp: The variance analysis of mean for 5 parent lines, found all lines had statistically nonsignificant. For the variance analysis of mean for 10 hybrids, found that all hybrids had statistically nonsignificant.

Table 4.2 Analysis of the variance of fruit and yield component characteristics of green-fleshed galia-melon.

[1/]source of variance	df	Mean of squares									
		[2/]FWe	FWi	FL	FCW	FCL	FPuT	FPeT	TSS	Fn	PFP
Genotype	14	0.17**	1.79**	30.10**	1.99	3.83**	0.14**	0.01	2.34	75.95	4.43
Parent	4	0.10**	1.57**	3.74**	0.30	1.99*	0.11*	0.02	2.02	143.47	5.02
Hybrids	9	0.14**	1.20**	45.04**	2.91	4.39**	0.12**	0.01	1.97	47.61	4.45
P vs. H	1	0.56**	5.60**	2.95*	0.22	4.77**	0.42**	0.01	8.41*	2.40	4.81
error	30	0.02	0.29	0.69	2.10	0.51	0.03	0.01	1.12	51.48	5.67
% CV	-	11.92	4.28	6.41	27.8	8.05	5.73	31.86	8.06	27.24	4.95

[1/]Genotype = all hybrids, Parent = comparison among the parent lines, Hybrids = comparison among the hybrids and P vs. H = class comparisons between parent lines and hybrids

[2/]FWe = Fruit weight (kg), FWi = Fruit width (cm), FL = Fruit length (cm), FCW = Fruit cavity width (cm), FCL = Fruit cavity length (cm), FPuT = Fruit pulp thickness (cm), FPeT = Fruit peel thickness (cm), TSS = Total soluble solid (%brix), Fn = Firmness (N) and PFP = percentage of fruit pulp (%).

Note: *: Significant at the 0.05 level and **: Significant at 0.01 level.

Table 4.3 The average of fruit and yield component characteristics of 5 parent lines in green-fleshed galia-melon.

Lines	2/Mean ± S.E.									
	1/FWe	FWi	FL	FCW	FCL	FPuT	FPeT	TSS	Fn	PFP
A1	1.05±0.04a	12.13±0.16ab	14.12±0.24a	5.04±0.12ab	8.76±0.22a	2.96±0.09ab	0.25±0.02	12.31±0.61	15.73±2.43	48.77±1.04
A2	1.08±0.11a	12.33±0.38a	13.63±0.55a	4.28±0.30c	8.50±0.50a	3.03±0.07a	0.51±0.23	12.25±1.20	41.90±0.00	49.14±0.86
A3	0.81±0.16b	11.27±0.66bc	11.80±1.34b	5.27±0.50a	6.77±0.93b	2.64±0.18bc	0.26±0.05	13.50±2.02	22.40±0.00	46.84±0.45
A4	0.70±0.06b	10.80±0.29c	11.20±0.48b	4.9±0.25ab	6.95±0.42b	2.56±0.09c	0.19±0.02	12.40±1.68	32.30±9.06	47.46±1.61
A5	1.22±0.00a	13.00±0.00a	14.40±0.00a	5.70±0.00a	9.00±0.00a	2.88±0.00a-c	0.28±0.00	10.50±0.00	25.20±0.00	44.23±0.00
F-test	**	**	**	*	**	*	ns	ns	ns	ns
%CV	24.83	7.92	13.14	12.41	15.83	10.43	74.75	21.83	49.31	6.22

1/FWe = Fruit weight (kg), FWi = Fruit width (cm), FL = Fruit length (cm), FCW = Fruit cavity width (cm), FCL = Fruit cavity length (cm), FPuT = Fruit pulp thickness (cm), FPeT = Fruit peel thickness (cm), TSS = Total soluble solid (%brix), Fn = Firmness (N) and PFP = Percentage of fruit pulp (%)

2/Mean ± S.E. followed by Duncan's New Multiple Range Test (DMRT) (P<0.05), ns = non-significant and *, ** = significant at p=<0.05 and 0.01 respectively.

Table 4.4 The average of fruit and yield component characteristics of F_1 hybrids in green-fleshed galia-melon.

Lines	[2/]Mean ± S.E.									
	[1/]FWe	FWi	FL	FCW	FCL	FPuT	FPeT	TSS	Fn	PFP
A12	1.53±0.11a	13.73±0.40a	15.71±0.42ab	5.14±1.61	9.95±0.36ab	3.45±0.12a	0.27±0.04	13.26±0.45a-d	26.02±2.94	50.39±1.12
A13	0.81±0.17d	11.25±0.63d	12.13±0.67d	5.00±2.55	7.43±0.58c	2.49±0.18c	0.31±0.07	12.63±0.71b-d	24.60±4.64	43.84±1.78
A14	1.43±0.14a	13.4±0.51ab	14.92±0.55ab	5.07±2.08	9.37±0.47ab	3.22±0.15ab	0.35±0.06	13.28±0.58a-d	25.02±3.79	47.98±1.45
A15	1.54±0.14a	13.72±0.51a	16.07±0.55a	5.12±2.08	10.48±0.47ab	3.19±0.15ab	0.35±0.06	13.83±0.58a-c	28.08±3.79	46.54±1.45
A23	1.41±0.13ab	13.23±0.48ab	15.30±0.51ab	4.79±1.93	9.66±0.43ab	3.20±0.14ab	0.47±0.05	14.63±0.54a	28.03±3.51	48.46±1.34
A24	1.28±0.13a-c	13.07±0.48ab	14.20±0.51bc	4.24±1.93	9.27±0.43b	3.18±0.14ab	0.27±0.05	11.71±0.54d	19.29±3.51	48.50±1.34
A25	1.48±0.09a	13.28±0.35ab	16.16±0.37a	8.44±1.42	10.73±0.32a	3.24±0.10ab	0.36±0.04	13.02±0.39a-d	33.66±2.58	48.75±0.99
A34	1.01±0.09cd	12.15±0.35a-c	12.55±0.37d	5.26±1.42	7.25±0.32c	2.90±0.10b	0.28±0.04	14.36±0.39ab	25.15±2.58	47.86±0.99
A35	0.98±0.15cd	11.90±0.56cd	13.06±0.6cd	4.90±2.28	7.68±0.51c	3.00±0.17ab	0.21±0.06	14.70±0.64a	26.84±4.15	50.51±1.59
A45	1.03±0.14b-d	12.18±0.51a-c	12.57±0.55d	5.25±2.08	7.62±0.47c	2.92±0.15b	0.28±0.06	12.5±0.58cd	33.67±3.79	48.05±1.45
F-test	**	**	**	ns	**	**	ns	**	ns	ns
%CV	30.87	10.28	13.11	78.75	18.23	12.73	41.05	11.44	35.4	7.69

[1/]FWe = fruit weight (kg), FWi = fruit width (cm), FL = fruit length (cm), FCW = fruit cavity width (cm), FCL = fruit cavity length (cm), FPuT = fruit pulp thickness (cm), FPeT = fruit peel thickness (cm), TSS = total soluble solid (%brix), Fn = firmness (N) and PFP = percentage of fruit pulp (%)

[2/]Mean ± S.E. followed by Duncan's New Multiple Range Test (DMRT) ($P<0.05$), ns = non-significant and *, ** = significant at p=<0.05 and 0.01 respectively.

4.1.2 Combining ability test of lines

The analysis of variance for general combining ability (GCA) of fruit components and yield characteristics in green fleshed galia melons, it was found significant statistical difference (P<0.01) for fruit weight, fruit width, fruit length, fruit cavity length and fruit pulp thickness. For the analysis of variance for specific combined ability (SCA) of fruit components and yield characteristics, it was found significant statistical difference (P<0.01) for fruit weight, fruit width, fruit length and fruit cavity length (Table 4.5), the details are as follows (Table 4.6 and Table 4.7).

Fruit weight: The analysis of variance for GCA of 5 parentals, it was found A2 line has positive and statistically high in GCA values (0.16). The lines A3 and A4 had negative and statistically high in GCA values (-0.16 and -0.11, respectively). For the analysis of variance for SCA of F_1 hybrids, it was found the hybrids A14 and A23 had positive and statistically high in SCA values (0.27 and 0.25, respectively). The hybrids A45 and A25 had negative and statistically high in SCA values (-0.29 and -0.22, respectively).

Fruit width: The analysis of variance for GCA of 5 parentals, it was found A2 line has positive and statistically high in GCA values (0.52). The lines A3 and A4 had negative and statistically high in GCA values (-0.55 and -0.36, respectively). For the analysis of variance for SCA of F_1 hybrids, it was found the hybrids A14, A24 and A23 had positive and statistically high in SCA values (0.96, 0.76 and 0.67, respectively). The hybrids A45 and A25 had negative and statistically high in SCA values (-1.09 and -0.90, respectively).

Fruit length: The analysis of variance for GCA of 5 parentals, it was found A2 and A5 lines had positive and statistically high in GCA values (1.86 and 1.36, respectively). The lines A4, A1 and A3 had negative and statistically high in GCA values (-1.36, -1.06 and -0.83, respectively). For the analysis of variance for SCA of F_1 hybrids, it was found the hybrids A15, A12, A34, A23, A35 and A45 had positive and statistically high in SCA values (5.77, 1.89, 1.84, 1.58, 1.12 and 1.12, respectively). The hybrids A13, A14 and A25 had negative and statistically high in SCA values (-5.81, -5.28 and -2.27, respectively).

Table 4.5 Analysis of variance for combining ability, GCA : SCA variances and ratio for fruit components and yield characteristics in green-fleshed galia melon.

Source of variance	df	[1/]FWe	FWi	FL	FCW	FCL	FPuT	FPeT	TSS	Fn	PFP
GCA	4	0.28**	3.07**	34.07**	0.77	7.34**	0.24**	0.02	3.03	94.37	6.35
SCA	10	0.11**	1.25**	25.05**	2.20	1.94**	0.09*	0.01	2.10	66.09	4.29
error	30	0.02	0.29	0.69	2.10	0.51	0.03	0.01	1.12	51.48	5.67
[2/]GCA/SCA		0.39	0.42	0.20	-2.03	0.69	0.50	-0.75	0.29	0.42	-0.07

[1/]FWe = Fruit weight (kg), FWi = Fruit width (cm), FL = Fruit length (cm), FCW = Fruit cavity width (cm), FCL = Fruit cavity length (cm), FPuT = Fruit pulp thickness (cm), FPeT = Fruit peel thickness (cm), TSS = Total soluble solid (%brix), Fn = Firmness (N) and PFP = Percentage of fruit pulp (%).

[2/]GCA/SCA = GCA component/SCA component.

Note: *: Significant at the 0.05 level and **: Significant at 0.01 level.

Table 4.6 Estimates of general and specific combining ability effects in parental genotypes and F_1 hybrids for fruit weight, fruit width, fruit length, fruit cavity width and fruit cavity length in green-fleshed galia melon.

Genotype	1/FWe	FWi	FL	FCW	FCL
GCA					
A1	0.04	0.12	-1.06**	-0.15	0.29
A2	0.16**	0.52**	1.88**	0.02	0.80**
A3	-0.16**	-0.55**	-0.83**	-0.08	-0.74**
A4	-0.11**	-0.36**	-1.36**	-0.23	-0.68**
A5	0.06	0.26	1.38**	0.43	0.33
SCA					
A12	0.12	0.43	1.89**	0.04	-0.08
A13	-0.09	-0.34	-5.81**	0.13	-0.56
A14	0.27**	0.96**	-5.28**	0.27	0.97*
A15	-0.10	-0.42	5.77**	-0.56	0.23
A23	0.25**	0.76*	1.58**	-0.27	1.13**
A24	0.19*	0.67*	1.22**	-0.60	0.68
A25	-0.22**	-0.90**	-2.27**	1.58	-0.39
A34	0.09	0.47	1.84**	0.26	-0.12
A35	-0.15	-0.49	1.12*	-0.39	-0.37
A45	-0.29**	-1.09**	1.12*	-0.07	-1.08**

1/FWe = Fruit weight (kg), FWi = Fruit width (cm), FL = Fruit length (cm), FCW = Fruit cavity width (cm) and FCL = Fruit cavity length (cm).

Note: *: Significant at the 0.05 level and **: Significant at 0.01 level.

Table 4.7 Estimates of general and specific combining ability effects in parental genotypes and F_1 hybrids for fruit pulp thickness, fruit peel thickness, sweetness, firmness, and percentage of fruit pulp in green-fleshed galia melon.

Genotype	[1/]FPuT	FPeT	TSS	Fn	PFP
GCA					
A1	0.03	-0.01	-0.04	-3.20	0.04
A2	0.17**	0.05*	-0.04	3.76	0.16
A3	-0.14**	0.01	0.76**	-1.70	-0.16
A4	-0.09*	-0.04	-0.14	-0.63	-0.11
A5	0.03	-0.03	-0.54	1.77	0.06
SCA					
A12	0.20*	-0.07	0.39	-1.87	0.12
A13	-0.24*	0.02	-1.13	2.51	-0.09
A14	0.22*	0.08	0.87	4.48	0.27
A15	-0.08	0.005	0.49	0.05	-0.10
A23	0.13	0.09	0.78	-2.41	0.25
A24	0.17	-0.04	-0.40	-11.40**	0.19
A25	-0.24*	0.02	-0.03	8.29	-0.22
A34	0.13	0.01	0.38	0.28	0.09
A35	0.01	-0.06	0.60	0.81	-0.15
A45	-0.23*	-0.01	-0.53	4.59	-0.29

[1/]FPuT = Fruit pulp thickness (cm), FPeT = Fruit peel thickness (cm), TSS = Total soluble solid (%brix), Fn = Firmness (N) and PFP = Percentage of fruit pulp (%).

Note: *: Significant at the 0.05 level and **: Significant at 0.01 level.

Fruit cavity width: The analysis of variance for GCA of 5 parentals, it was found all lines had statistical nonsignificant for GCA values. The analysis of variance for SCA of F_1 hybrids, it was found all hybrids had statistical nonsignificant for SCA values.

Fruit cavity length: The analysis of variance for GCA of 5 parentals, it was found A2 line has positive and statistically high in GCA values (0.80). The lines A3 and A4 had negative and statistically high in GCA values (-0.74 and -0.68, respectively). For the analysis of variance for SCA of F_1 hybrids, it was found the hybrids A23 and A14 had positive and statistically high in SCA values (1.13 and 0.97, respectively). The hybrid A45 has negative and statistically high in SCA values (-1.08).

Fruit pulp thickness: The analysis of variance for GCA of 5 parentals, it was found A2 line has positive and statistically high in GCA values (0.17). The lines A3 and A4 had negative and statistically high in GCA values (-0.14 and -0.09, respectively). For the analysis of variance for SCA of F_1 hybrids, it was found the hybrids A14 and A12 had positive and statistically high in SCA values (0.22 and 0.20, respectively). The hybrids A13, A25 and A45 had negative and statistically high in SCA values (-0.24, -0.24 and -0.23, respectively).

Fruit peel thickness: The analysis of variance for GCA of 5 parentals, it was found A2 line has positive and statistically high in GCA values (0.05). For the analysis of variance for SCA of F_1 hybrids, it was found all hybrids had statistical nonsignificant for SCA values.

TSS: The analysis of variance for GCA of 5 parentals, it was found A3 line has positive and statistically high in GCA values (0.76). For the analysis of variance for SCA of F_1 hybrids, it was found all hybrids had statistical nonsignificant for SCA values.

Firmness: The analysis of variance for GCA of 5 parentals, it was found all lines had statistical nonsignificant for GCA values. For the analysis of variance for SCA of F_1 hybrids, it was found the hybrids A24 has negative and statistically high in SCA values (-11.40).

Percentage of fruit pulp: The analysis of variance for GCA of 5 parentals, it was found all lines had statistical nonsignificant for GCA values. The analysis of variance for SCA of F_1 hybrids, it was found all hybrids had statistical nonsignificant for SCA values.

4.1.3 Heterosis of F_1 hybrids in green-fleshed galia melon

The heterosis (H) and heterobeltiosis (HB) of F_1 hybrids in green-fleshed galia melons, it was found the most had positive values for the fruit components and yield (Table 4.8), the details are as follows (Table 4.9 and Table 4.10).

Fruit weight: The analysis of variance for heterosis of F_1 hybrids, it was found the hybrids A14, A12 and A45 had positive and statistically high in heterosis values (53.49%, 47.28% and 12.67%, respectively).

Fruit width: The analysis of variance for heterosis of F_1 hybrids, it was found the hybrids A24, A14 and A45 had positive and statistically high in heterosis values (16.89%, 15.03% and 4.40%, respectively).

Fruit length: The analysis of variance for heterosis of F_1 hybrids, it was found the hybrids A24 and A15 had positive and statistically high in heterosis values (19.27% and 9.07%, respectively).

Fruit cavity width: The analysis of variance for heterosis of F_1 hybrids, it was found all hybrids had statistical nonsignificant for heterosis values. The hybrids A35, A15, A13 and A45 had negative heterosis value (-10.47%, -8.61%, -0.94% and -0.24%, respectively).

Fruit cavity length: The analysis of variance for heterosis of F_1 hybrids, it was found the hybrids A24, A25 and A15 had positive and statistically high in heterosis values (27.67%, 25.01 and 14.36%, respectively). The hybrids A45 and A13 had negative heterosis value (-2.83% and -0.14%, respectively).

Fruit pulp thickness: The analysis of variance for heterosis of F_1 hybrids, it was found the hybrids A24, A14 and A15 had positive and statistically high in heterosis values (16.62%, 13.36% and 6.36%, respectively).

Fruit peel thickness: The analysis of variance for heterosis of F_1 hybrids, it was found the hybrid A14 has positive and statistically high in heterosis values (48.92%). The hybrid A12 has negative heterosis value (-18.39%).

TSS: The analysis of variance for heterosis of F_1 hybrids, it was found the hybrids A15 and A23 had positive and statistically high in heterosis values (19.32% and 12.43%, respectively).

Firmness: The analysis of variance for heterosis of F_1 hybrids, it was found all hybrids had statistical nonsignificant for heterosis values.

Percentage of fruit pulp: The analysis of variance for heterosis of F_1 hybrids, it was found the hybrid A13 has negative and statistically high in heterosis values (-6.03%).

4.1.4 Correlation between fruit components and yield characteristics of green-fleshed galia melon

Results of the correlation analysis between fruit and yield of green fleshed galia melons (Table 4.11). It was found that: **fruit weight** was correlated with fruit width (r=0.969), fruit length (r=0.929), fruit cavity width (r=0.255), fruit cavity length (r=0.860), fruit pulp thickness (r=0.818), and fruit pulp thickness (r=0.818) and fruit peel thickness (r=0.248). There was non-correlation with sweetness (r=0.08), firmness (r=0.046) and percentage of pulp (r=0.056). **Fruit width** was correlated with fruit length (r=0.881), fruit cavity width (r=0.228), fruit cavity length (r=0.810), fruit pulp thickness (r=0.831) and fruit peel thickness (r=0.222). There was non-correlation with sweetness (r=0.08), firmness (r=-0.057), and percentage of pulp (r=0.034). **Fruit length** was correlated with fruit cavity width (r=0.231), fruit cavity length (r=0.928), fruit pulp thickness (r=0.759) and fruit peel thickness (r=0.224). There was non-correlation with sweetness (r=0.035), firmness (r=0.09), and percentage of pulp (r=0.074). **Fruit cavity width** was correlated with fruit cavity length (r=0.187). There was non-correlation with fruit pulp thickness (r=0.17), fruit peel thickness (r=-0.073), sweetness (r=-0.061), firmness (r=0.048), and percentage of pulp (r=-0.035). **Fruit cavity length** was correlated with fruit pulp thickness (r=0.695) and fruit peel thickness (r=0.201). There was non-correlation with sweetness (r= 0.001), firmness (r=0.074), and percentage of pulp (r=0.065). **Fruit pulp thickness** was correlated with percentage of pulp (r=0.581). There was non-correlation with fruit peel thickness (r=0.133), sweetness (r=0.067) and firmness (r=-0.062). **Fruit peel thickness** was correlated with sweetness (r=0.195), firmness (r=0.242) and percentage of pulp (r=-0.246). **TSS (sweetness)** was correlated with firmness (r=-0.242). There was non-correlation with percentage of pulp (r=-0.006). **Firmness** non-correlation with percentage of pulp (r= -0.013) at 0.05 and 0.01 significance levels.

Table 4.8 Mean of parents, mean of first-generation, highest-lowest percentage of heterosis and the number of hybrids with positive or negative dominance in the fruit components and yield of green-fleshed galia melon.

	[1/]FWe	FWi	FL	FCW	FCL	FPuT	FPeT	TSS	Fn	PFP
Parents average	0.97	11.92	13.26	5.10	8.18	2.86	0.28	12.25	26.54	47.30
Hybrid average	1.21	12.71	12.96	5.26	8.71	3.07	0.31	13.25	27.75	48.37
Heterosis										
% Lowest	0.10	-0.82	-1.53	-10.47	-2.83	-5.29	-18.39	-1.72	-34.85	-6.03
% Maximum	67.62	16.89	24.89	52.30	35.77	16.62	48.92	22.19	49.98	7.69
- hybrids	0	1	1	3	2	1	1	2	3	3
+ hybrids	0	9	9	7	8	9	9	8	7	7
Heterobeltiosis										
% Lowest	-1.89	-1.01	-1.36	-10.19	-2.57	-4.75	-10.86	-1.60	-23.33	-5.93
% Maximum	59.57	16.09	22.32	46.45	31.47	15.52	42.42	20.27	42.29	7.46
- hybrids	1	1	2	3	2	1	1	2	3	3
+ hybrids	9	9	8	7	8	9	9	8	7	7

[1/]FWe = Fruit weight (kg), FWi = Fruit width (cm), FL = Fruit length (cm), FCW = Fruit cavity width (cm), FCL = Fruit cavity length (cm), FPuT = Fruit pulp thickness (cm), FPeT = Fruit peel thickness (cm), TSS = Total soluble solid (%brix), Fn = Firmness (N) and PFP = Percentage of fruit pulp (%).

Table 4.9 Estimates of heterosis over the mid parent (MP) and better parent (HP) for Fruit weight, fruit width, fruit length, fruit cavity width and fruit cavity length in green-fleshed galia melon.

Hybrids/ genotype	[1/]FWe		FWi		FL		FCW		FCL	
	[2/]H	HB	H	HB	H	HB	H	HB	H	HB
A12	47.28*	43.98	13.02	12.76	14.19	13.68	12.24	11.25	17.03	16.53
A13	0.44	2.20	0.15	0.40	-1.53	-1.36	-0.94	-0.83	-0.36	-0.14
A14	53.49*	44.75	15.03*	14.20	15.24	13.62	4.47	4.34	17.48	15.66
A15	22.71*	21.14	4.96	4.79	9.07**	8.98	-8.61	-8.00	14.36*	14.00
A23	63.04	51.40	14.15	13.30	24.89	22.32	6.05	6.29	35.77	31.47
A24	67.62	59.57	16.89*	16.09	19.27*	17.94	1.77	1.73	27.67**	25.88
A25	31.98	27.73	5.23	4.90	16.66	15.85	52.30	46.45	25.01*	23.62
A34	34.03	31.13	9.59	9.26	9.06	8.60	3.51	3.38	7.39	6.84
A35	0.10	-1.89	-0.82	-1.01	0.42	-0.29	-10.47	-10.19	1.19	0.00
A45	12.67*	9.98	4.40*	4.03	0.25	0.20	-0.24	-0.30	-2.83	-2.57

[1/]FWe = fruit weight (kg), FWi = fruit width (cm), FL = fruit length (cm), FCW = fruit cavity width (cm) and FCL = fruit cavity length (cm).

[2/]H = % of heterosis and HB = % of heterobetiosis.

Note: *: Significant at the 0.05 level and **: Significant at 0.01 level.

Table 4.10 Estimates of heterosis over the mid parent (MP) and better parent (HP) for Fruit pulp thickness, fruit peel thickness, sweetness, firmness, and percentage of fruit pulp in green-fleshed galia melon.

Hybrids/ genotype	[1/]FPuT		FPeT		TSS		Fn		PFP	
	[2/]H	HB	H	HB	H	HB	H	HB	H	HB
A12	14.68	14.41	-18.39	-10.86	9.30	8.36	0.44	0.30	1.61	1.60
A13	-5.29	-4.75	29.49	24.24	-1.72	-1.60	23.68	18.98	-6.03*	-5.93
A14	13.36*	12.48	48.92*	42.42	11.60	10.16	41.28	42.29	-1.42	-1.41
A15	6.36*	6.27	24.20	22.99	19.32**	17.90	49.98	40.36	1.49	1.42
A23	13.98	12.85	19.82	14.16	12.43*	10.44	11.83	10.47	0.10	0.17
A24	16.62**	15.52	1.26	7.75	-0.23	-0.18	-34.85	-23.33	-0.12	-0.09
A25	9.87	9.78	3.77	4.36	15.87	14.55	-5.28	-4.23	4.31	4.16
A34	12.82	12.63	25.54	20.79	13.64	13.34	-25.71	-19.70	2.66	2.61
A35	6.94	6.38	5.40	2.53	22.19	20.27	7.57	7.15	7.69	7.46
A45	8.92	8.26	29.94	22.99	9.99	8.82	25.51	19.84	4.16	4.18

[1/] FPuT = Fruit pulp thickness (cm), FPeT = Fruit peel thickness (cm), TSS = Total soluble solid (%brix), Fn = Firmness (N) and PFP = Percentage of fruit pulp (%).

[2/]H = % of heterosis and HB = % of heterobetiosis.

Note: *: Significant at the 0.05 level and **: Significant at 0.01 level.

Table 4.11 The correlation coefficient of fruit components and yield characteristics in green-fleshed galia melon.

Correlations									
	Fruit width	Fruit length	Fruit cavity width	Fruit cavity length	Fruit pulp thickness	Fruit peel thickness	TSS	Firmness	%Pulp
Fruit weight	0.969**	0.929**	0.255**	0.860**	0.818**	0.248**	0.080	0.046	0.056
Fruit width		0.881**	0.228**	0.810**	0.831**	0.222*	0.080	-0.057	0.034
Fruit length			0.231**	0.928**	0.759**	0.224*	0.035	0.090	0.074
Fruit cavity width				0.187*	0.170	-0.073	-0.061	0.048	-0.035
Fruit cavity length					0.695**	0.201*	0.001	0.074	0.065
Fruit pulp thickness						0.133	0.067	-0.062	0.581**
Fruit peel thickness							0.195*	0.242*	-0.246**
TSS								-0.242*	-0.006
Firmness									-0.013

Note: *: Significant at the 0.05 level and **: Significant at 0.01 level.

4.2 Orange-fleshed galia melons

4.2.1 Analysis of variance

The variance analysis of 10 recorded characteristics were fruit weight, fruit width, fruit length, fruit cavity width, fruit cavity length, fruit pulp thickness, fruit peel thickness, sweetness, firmness, and percentage of fruit pulp, it was found that all characteristics showed a statistically significant difference due to genotype ($P<0.01$). For the comparison among the parent lines, it was found that all characteristics but except was fruit peel thickness, there were statistically significant difference. For the comparison among the hybrids, it was found that all characteristics, there were statistically significant difference. Class comparisons between parent lines and hybrids, it was found that the fruit weight, fruit width, fruit length, fruit cavity length, fruit pulp thickness and fruit peel thickness, there were significantly different (Table 4.12). The variance analysis of mean of 7 parent lines and 21 hybrids, the detail follow (Table 4.13 and Table 4.14).

Fruit weight: The variance analysis of mean for 7 parent lines, found that the lines B2, B3 and B6 had high average and statistically significant (1.26, 1.11 and 1.26 kg, respectively). For the variance analysis of mean for 21 hybrids, found that the hybrid B23 has high average and statistically significant (1.60 kg).

Fruit width: The variance analysis of mean for 7 parent lines, found that the lines B2, B3, B6, B7 and B8 had high average and statistically significant (12.63, 12.30, 13.11, 12.28 and 12.06 cm, respectively). For the variance analysis of mean for 21 hybrids, found that the hybrid B23 has high average and statistically significant (13.48 cm).

Fruit length: The variance analysis of mean for 7 parent lines, found that the line B2 has high average and statistically significant (16.30 cm). For the variance analysis of mean for 21 hybrids, found that the hybrid B23 has high average and statistically significant (17.30 cm).

Fruit cavity width: The variance analysis of mean for 7 parent lines, found that the line B4 has low average and statistically significant (4.60 cm). For the variance analysis of mean for 21 hybrids, found that the hybrid B37 has low average and statistically significant (4.63 cm).

Fruit cavity length: The variance analysis of mean for 7 parent lines, found that the line B4 has low average and statistically significant (5.40 cm). For the variance analysis of mean for 21 hybrids, found that the hybrid B14 has low average and statistically significant (6.70 cm).

Fruit pulp thickness: The variance analysis of mean for 7 parent lines, found that the line B3 has high average and statistically significant (3.13 cm). For the variance analysis of mean for 21 hybrids, found that the hybrids B23 has high average and statistically significant (3.58 cm).

Fruit peel thickness: The variance analysis of mean for 7 parent lines, found the lines B2, B4 and B7 had low average and statistically significant (0.23, 0.26 and 0.33 cm, respectively). For the variance analysis of mean for 21 hybrids, found that the hybrids B14, B48 and B78 had low average and statistically significant (0.36, 0.39 and 0.45 cm, respectively).

TSS: The variance analysis of mean for 7 parent lines, found the line B4 has high average and statistically significant (17.18 brix). For the variance analysis of mean for 21 hybrids, found that the hybrid B48 has high average and statistically significant (16.20 brix).

Firmness: The variance analysis of mean for 7 parent lines, found the lines B8 has high average and statistically significant (40.93 N). For the variance analysis of mean for 21 hybrids, found that the hybrid B78 has high average and statistically significant (40.45 N).

Percentage of fruit pulp: The variance analysis of mean for 7 parent lines, found the lines B3 has high average and statistically significant (50.81%). For the variance analysis of mean for 21 hybrids, found that the hybrid B23 has high average and statistically significant (53.05%).

Table 4.12 Analysis of the variance of fruit and yield component characteristics of orange-fleshed galia-melon.

[1/]source of variance	df	Mean of squares									
		[2/]FWe	FWi	FL	FCW	FCL	FPuT	FPeT	TSS	Fn	PFP
Genotype	27	0.13**	1.51**	5.99**	0.52**	4.47**	0.22**	0.07**	5.30**	61.27**	23.29**
Parent	6	0.15**	2.67**	8.38**	0.62*	7.29**	0.28**	0.02	11.62**	87.72**	23.18**
Hybrids	20	0.11**	1.03**	4.60**	0.52*	3.15**	0.20**	0.06**	3.20**	53.49**	25.95**
P vs. H	1	0.29**	3.36**	11.55**	0.007	7.85**	0.24*	0.40**	1.11	3.85	3.27
error	56	0.02	0.31	1.04	0.23	0.61	0.04	0.01	0.52	20.98	5.91
% CV		13.01	4.53	7.25	8.91	8.81	7.74	21.35	5.09	15.39	5.51

[1/]Genotype = all hybrids, Parent = comparison among the parent lines, Hybrids = comparison among the hybrids and P vs. H = class comparisons between parent lines and hybrids.

[2/]FWe = Fruit weight (kg), FWi = Fruit width (cm), FL = Fruit length (cm), FCW = Fruit cavity width (cm), FCL = Fruit cavity length (cm), FPuT = Fruit pulp thickness (cm), FPeT = Fruit peel thickness (cm), TSS = Total soluble solid (%brix), Fn = Firmness (N) and PFP = Percentage of fruit pulp (%).

Note: *: Significant at the 0.05 level and **: Significant at 0.01 level.

Table 4.13 The average of fruit and yield component characteristics of 7 parent lines in orange-fleshed galia-melon.

Lines	2/Mean ± S.E.									
	1/FWe	FWi	FL	FCW	FCL	FPuT	FPeT	TSS	Fn	PFP
B1	0.75±0.14bc	10.37±0.83b	12.03±0.59d	5.47±0.32a-c	8.07±0.52b	2.01±0.21d	0.23±0.11b	15.10±0.49b	28.55±3.05bc	38.75±2.73d
B2	1.26±0.12a	12.63±0.23a	16.30±0.23a	5.07±0.23a-c	11.17±0.44a	2.95±0.13ab	0.42±0.05ab	11.07±0.52d	22.70±0.00c	46.69±1.61b
B3	1.11±0.00a	12.30±0.00a	13.70±0.00bc	4.80±0.00bc	7.50±0.00b	3.13±0.00a	0.58±0.00a	15.00±0.00b	29.50±0.00a-c	50.81±0.00a
B4	0.53±0.03c	9.98±0.13b	10.55±0.37e	4.60±0.20c	5.40±1.04c	2.09±0.05d	0.26±0.09b	17.18±0.43a	26.37±3.76bc	41.88±1.28cd
B6	1.26±0.05a	13.11±0.21a	14.37±0.21b	5.93±0.16a	9.03±0.18b	2.79±0.07a-c	0.42±0.03ab	14.59±0.27b	24.82±1.01bc	42.61±0.82cd
B7	1.02±0.12ab	12.28±0.44a	13.12±0.63b-d	5.62±0.18ab	8.62±0.39b	2.56±0.11c	0.33±0.06b	11.83±0.98cd	36.4±4.88ab	41.65±0.96cd
B8	1.01±0.13ab	12.06±0.49a	12.74±0.67cd	5.90±0.48a	7.44±0.46b	2.66±0.12bc	0.39±0.06ab	13.18±0.52bc	40.93±5.99a	44.04±1.07bc
F-test	**	**	**	**	**	**	*	**	*	**
%CV	29.95	10.94	13.3	13.28	20.8	15.07	38.3	15.45	28.86	8.88

1/FWe = Fruit weight (kg), FWi = Fruit width (cm), FL = Fruit length (cm), FCW = Fruit cavity width (cm), FCL = Fruit cavity length (cm), FPuT = Fruit pulp thickness (cm), FPeT = Fruit peel thickness (cm), TSS = Total soluble solid (%brix), Fn = Firmness (N) and PFP = Percentage of fruit pulp (%).

2/Mean ± S.E. followed by Duncan's New Multiple Range Test (DMRT) ($P<0.05$), ns = non-significant and *, ** = significant at $p=<0.05$ and 0.01 respectively.

Table 4.14 The average of F_1 hybrids for fruit weight, fruit width, fruit length, fruit cavity width and fruit cavity length in orange-fleshed galia-melon.

Lines	[2/]Mean ± S.E.				
	[1/]FWe	FWi	FL	FCW	FCL
B12	1.35±0.17a-d	13.10±0.59a-d	15.25±1.13a-c	5.40±0.51b-e	9.75±0.82a-e
B13	0.93±0.08fg	11.70±0.26e-g	12.75±0.51de	5.47±0.23b-e	7.45±0.37gh
B14	0.73±0.12g	11.00±0.42g	11.73±0.80e	5.18±0.36c-e	6.70±0.58h
B16	1.08±0.09c-f	12.33±0.32a-f	13.76±0.60c-e	5.50±0.27b-e	8.79±0.44c-g
B17	1.13±0.11b-e	12.38±0.37a-f	14.40±0.71b-d	5.40±0.32b-e	9.70±0.52a-e
B18	1.00±0.09d-g	12.21±0.32b-f	12.87±0.60de	5.97±0.27a-c	7.96±0.44f-h
B23	1.60±0.09a	13.48±0.29a	17.30±0.57a	4.85±0.25de	10.81±0.41ab
B24	1.14±0.14b-e	12.43±0.48a-f	15.03±0.92b-d	6.67±0.41a	9.67±0.67a-e
B26	1.45±0.09ab	13.29±0.32a-c	15.39±0.60a-c	5.39±0.27b-e	10.76±0.44ab
B27	1.47±0.09ab	13.36±0.29ab	15.51±0.57a-c	5.30±0.25c-e	10.19±0.41a-c
B28	1.38±0.10a-c	13.13±0.34a-d	16.18±0.65ab	5.82±0.29a-d	11.05±0.48a
B34	1.12±0.10b-e	12.37±0.34a-f	13.62±0.65c-e	5.42±0.29b-e	8.08±0.48e-h
B36	1.09±0.07c-f	12.14±0.22c-g	14.5±0.43b-d	4.99±0.19c-e	8.87±0.31c-g
B37	1.31±0.08a-e	12.83±0.28a-e	15.33±0.53a-c	4.63±0.24e	9.28±0.39b-f
B38	1.13±0.09b-e	12.55±0.29a-f	14.51±0.57b-d	5.26±0.25c-e	7.98±0.41f-h
B46	0.97±0.09e-g	12.04±0.32d-g	13.51±0.60c-e	5.50±0.27b-e	8.26±0.44d-h
B47	1.23±0.14b-e	12.97±0.48a-d	14.23±0.92b-d	5.60±0.41b-e	9.27±0.67b-f
B48	0.91±0.14fg	11.47±0.48fg	12.90±0.92de	5.27±0.41c-e	7.83±0.67f-h
B67	1.24±0.09b-e	12.84±0.32a-e	14.90±0.6b-d	5.47±0.27b-e	9.83±0.44a-d
B68	1.20±0.09b-e	12.60±0.29a-f	13.91±0.57b-e	6.41±0.25ab	9.19±0.41b-f
B78	0.97±0.09e-g	11.71±0.29e-g	13.58±0.57c-e	4.98±0.25c-e	8.90±0.41c-g
F-test	**	**	**	**	**
%CV	27.26	8.15	13.69	14.01	17.37

[1/]FWe = Fruit weight (kg), FWi = Fruit width (cm), FL = Fruit length (cm), FCW = Fruit cavity width (cm) and FCL = fruit cavity length (cm).

[2/]Mean ± S.E. followed by Duncan's New Multiple Range Test (DMRT) (P<0.05), ns = non-significant and *, ** = significant at p=<0.05 and 0.01 respectively.

Table 4.15 The average of F_1 hybrids for fruit pulp thickness, fruit peel thickness, sweetness, firmness, and percentage of pulp in orange-fleshed galia-melon.

Lines	2/Mean ± S.E.				
	1/FPuT	FPeT	TSS	Fn	PFP
B12	3.06±0.21b	0.50±0.17a-c	15.50±0.86ab	24.60±4.23c-f	46.52±2.39bc
B13	2.56±0.09d-f	0.56±0.08a-c	14.55±0.39a-e	29.16±1.89b-f	43.64±1.07b-g
B14	2.51±0.15d-f	0.36±0.12c	15.45±0.61ab	23.88±2.99d-f	45.54±1.69b-d
B16	2.54±0.11d-f	0.65±0.09a-c	14.60±0.46a-e	28.79±2.26b-f	41.17±1.28d-g
B17	2.43±0.13ef	0.67±0.11a-c	12.90±0.55ef	32.12±2.68b-d	39.23±1.51f-g
B18	2.36±0.11f	0.54±0.09a-c	14.50±0.46a-e	35.01±2.26ab	38.82±1.28g
B23	3.58±0.10a	0.51±0.09a-c	14.28±0.43b-e	29.19±2.12b-f	53.05±1.20a
B24	2.52±0.17d-f	0.59±0.14a-c	14.90±0.70a-d	21.13±3.46f	40.42±1.95e-g
B26	2.82±0.11b-e	0.82±0.09a	14.34±0.46b-e	27.21±2.26b-f	42.45±1.28b-g
B27	2.89±0.1b-d	0.71±0.09a-c	13.63±0.43c-e	32.93±2.12a-c	43.32±1.20b-g
B28	2.89±0.12b-d	0.48±0.10a-c	13.25±0.50c-e	30.63±2.44b-e	43.97±1.38b-f
B34	2.77±0.12b-f	0.80±0.10a	15.50±0.50ab	26.23±2.44b-f	44.69±1.38b-e
B36	2.61±0.08c-f	0.8±0.06ab	13.83±0.33b-e	27.12±1.60b-f	43.02±0.90b-g
B37	3.02±0.10bc	0.82±0.08a	13.94±0.41b-e	26.47±2.00b-f	47.17±1.13b
B38	2.93±0.10b-d	0.58±0.09a-c	14.44±0.43b-e	31.95±2.12b-d	46.60±1.20bc
B46	2.63±0.11c-f	0.47±0.09a-c	14.61±0.46a-e	22.29±2.26ef	43.68±1.28b-g
B47	2.71±0.17b-f	0.55±0.14a-c	15.00±0.70a-c	31.67±3.46b-d	41.72±1.95c-g
B48	2.56±0.17d-f	0.39±0.14c	16.20±0.70a	33.53±3.46ab	44.71±1.95b-e
B67	2.72±0.11b-f	0.80±0.09ab	13.36±0.46c-e	28.16±2.26b-f	42.39±1.28b-g
B68	2.68±0.10b-f	0.45±0.09bc	13.15±0.43d-f	29.60±2.12b-f	42.53±1.20b-g
B78	2.59±0.10d-f	0.42±0.09c	11.63±0.43f	40.45±2.12a	44.21±1.20b-e
F-test	**	**	**	**	**
%CV	13.31	46.37	10.56	23.62	9.77

1/FPuT = Fruit pulp thickness (cm), FPeT = Fruit peel thickness (cm), TSS = Total soluble solid (%brix), Fn = Firmness (N) and PFP = Percentage of fruit pulp (%).

2/Mean ± S.E. followed by Duncan's New Multiple Range Test (DMRT) (P<0.05), ns = non-significant and *, ** = significant at p=<0.05 and 0.01 respectively.

4.2.2 Combining ability test of lines

The analysis of variance for general combining ability (GCA) of fruit components and yield characteristics in orange fleshed galia melons, it was found significant statistical difference for all characteristics but except was fruit peel thickness. For the analysis of variance for specific combined ability (SCA) of fruit components and yield characteristics, it was found significant statistical difference for fruit weight, fruit width, fruit pulp thickness, fruit peel thickness and sweetness (Table 4.16), the details are as follows (Table 4.17 and Table 4.18).

Fruit weight: The analysis of variance for GCA of 7 parentals, it was found B2 line has positive and statistically high in GCA values (0.36). For the analysis of variance for SCA of 21 F_1 hybrids, it was found all hybrids had statistical nonsignificant for SCA values.

Fruit width: The analysis of variance for GCA of 7 parentals, it was found B2 line has positive and statistically high in GCA values (0.96). For the analysis of variance for SCA of 21 F_1 hybrids, it was found all hybrids had statistical nonsignificant for SCA values.

Fruit length: The analysis of variance for GCA of 7 parentals, it was found B2 and B3 lines had positive and statistically high in GCA values (3.32 and 1.91, respectively). For the analysis of variance for SCA of 21 F_1 hybrids, it was found the hybrids B18 and B34 had negative and statistically high in SCA values (-4.81 and -4.81, respectively).

Fruit cavity width: The analysis of variance for GCA of 7 parentals, it was found B8 line has negative and statistically high in GCA values (-0.98). The analysis of variance for SCA of 21 F1 hybrids, it was found all hybrids had statistical nonsignificant for SCA values.

Fruit cavity length: The analysis of variance for GCA of 7 parentals, it was found B2, B8 and B4 lines had positive and statistically high in GCA values (3.56, 1.60 and 1.44, respectively). The line B6 has negative and statistically high in GCA values (-8.39). For the analysis of variance for SCA of 21 F_1 hybrids, it was found the hybrids B18 and B34 had negative and statistically high in SCA values (-5.86 and -5.86, respectively).

Fruit pulp thickness: The analysis of variance for GCA of 7 parentals, it was found B1 line has negative and statistically high in GCA values (-0.37). For the analysis of variance for SCA of 21 F_1 hybrids, it was found all hybrids had statistical nonsignificant for SCA values.

Fruit peel thickness: The analysis of variance for GCA of 7 parentals, it was found B3 line has positive and statistically high in GCA values (0.20). For the analysis of variance for SCA of F_1 hybrids, it was found all hybrids had statistical nonsignificant for SCA values.

TSS: The analysis of variance for GCA of 7 parentals, it was found B4 lines has positive and statistically high in GCA values (2.93). The line B8 has negative and statistically high in GCA values (-1.90). For the analysis of variance for SCA of 21 F_1 hybrids, it was found the hybrids B78 and B27 had positive and statistically high in SCA values (4.43 and 1.71, respectively). The hybrid B14 has negative and statistically high in SCA values (-1.98).

Firmness: The analysis of variance for GCA of 7 parentals, it was found B7 line has negative and statistically high in GCA values (-9.20). For the analysis of variance for SCA of 21 F_1 hybrids, it was found all hybrids had statistical nonsignificant for SCA values.

Percentage of fruit pulp: The analysis of variance for GCA of 7 parentals, it was found B1 line has negative and statistically high in GCA values (-5.84). For the analysis of variance for SCA of 21 F_1 hybrids, it was found the hybrid B12 has positive and statistically high in SCA values (7.43).

Table 4.16 Analysis of variance for combining ability, GCA : SCA variances and ratio for fruit components and yield characteristics in orange-fleshed galia melon.

Source of variance	df	[1/]FWe	FWi	FL	FCW	FCL	FPuT	FPeT	TSS	Fn	PFP
GCA	6	0.08**	0.97*	4.74**	0.96**	4.19**	0.14*	0.02	6.80**	46.63	19.56**
SCA	21	0.05*	0.61*	1.58	0.36	1.02	0.09*	0.05**	2.05**	14.78	8.59
error	56	0.02	0.31	1.05	0.23	0.62	0.04	0.01	0.53	20.75	5.91
[2/]GCA/SCA		1.86	1.60	2.99	2.69	4.10	1.59	0.39	3.31	3.15	2.28

[1/]FWe = Fruit weight (kg), FWi = Fruit width (cm), FL = Fruit length (cm), FCW = Fruit cavity width (cm), FCL = Fruit cavity length (cm), FPuT = Fruit pulp thickness (cm), FPeT = Fruit peel thickness (cm), TSS = Total soluble solid (%brix), Fn = Firmness (N) and PFP = Percentage of fruit pulp (%).

[2/]GCA/SCA = GCA component/SCA component.

Note: *: Significant at the 0.05 level and **: Significant at 0.01 level.

Table 4.17 Estimates for GCA and SCA effects in parental and F_1 hybrids for fruit weight, fruit width, fruit length, fruit cavity width and fruit cavity length in orange-fleshed galia melon.

Genotype	[1/]FWe	FWi	FL	FCW	FCL
GCA					
B1	-0.04	-0.04	0.00	0.03	0.56
B2	0.36**	0.96*	3.32**	-0.22	3.56**
B3	0.14	0.36	1.91*	-0.63	0.83
B4	-0.13	-0.77	-0.05	-0.77	0.41
B6	-0.44	-0.34	-6.62	1.90	-8.39**
B7	0.16	0.30	0.61	0.66	1.44*
B8	-0.04	-0.47	0.83	-0.98*	1.60*
SCA					
B12	-0.01	-0.037	-0.87	-0.33	-1.73
B13	-0.12	-0.56	-1.67	0.24	-1.04
B14	-0.08	-0.29	-0.91	0.25	-1.03
B16	0.34	2.96	3.27	1.54	4.74
B17	-0.16	-0.30	-1.39	-1.04	-1.77
B18	-0.47	-1.09	-4.81*	0.08	-5.86**
B23	-0.02	0.16	-1.41	0.73	-0.79
B24	0.51	1.87	10.56	-0.36	6.86
B26	-0.24	-0.76	-0.82	-0.96	-0.76
B27	-0.03	-0.04	-3.16	0.45	-2.00
B28	-0.16	-0.30	-1.39	-1.04	-1.77
B34	-0.47	-1.09	-4.81*	0.08	-5.86**
B36	-0.02	0.16	-1.41	0.73	-0.79
B37	0.51	1.87	10.56	-0.36	6.86
B38	-0.24	-0.76	-0.82	-0.96	-0.76
B46	0.66	0.11	8.61	-3.44	10.73
B47	-0.09	0.22	0.10	-0.35	-0.96
B48	-0.06	0.68	-2.48	1.70	-3.67
B67	0.67	-0.29	0.53	6.16	7.20
B68	-2.16	-7.01	-16.13	-5.34	-18.14
B78	-0.01	1.03	0.98	-1.41	-1.82

[1/]FWe = Fruit weight (kg), FWi = Fruit width (cm), FL = Fruit length (cm), FCW = Fruit cavity width (cm) and FCL = Fruit cavity length (cm) **Note:** *: Significant at the 0.05 level and **: Significant at 0.01 level.

Table 4.18 Estimates for GCA and SCA effects in parental and F_1 hybrids for fruit pulp thickness, fruit peel thickness, sweetness, firmness, and percentage of pulp in orange-fleshed galia melon.

Genotype	1/FPuT	FPeT	TSS	Fn	PFP
GCA					
B1	-0.37*	0.16	0.99	-2.43	-5.84**
B2	0.24	0.08	-0.41	-6.43	0.39
B3	0.22	0.20*	0.68	-5.86	2.14
B4	-0.16	-0.01	2.93**	-4.40	0.40
B6	0.21	-0.54	-1.78	26.09	4.80
B7	-0.05	0.07	-0.52	-9.20**	-1.86
B8	-0.10	0.05	-1.90**	2.22	-0.05
SCA					
B12	0.47	-0.12	1.43	-4.48	7.43*
B13	0.07	-0.18	-0.51	-0.37	3.29
B14	0.23	-0.14	-1.98*	-7.23	4.59
B16	-1.55	1.10	0.40	23.45	-33.67
B17	0.22	0.05	0.62	2.78	4.21
B18	0.43	-0.31	0.43	-9.62	8.04
B23	0.37	-0.13	0.65	3.08	5.52
B24	-0.11	0.07	-0.43	-6.06	-0.97
B26	-0.15	0.11	-2.07	8.81	-14.29
B27	-0.02	0.19	1.71*	4.95	0.94
B28	-0.25	0.02	0.61	-3.92	0.35
B34	0.01	-0.01	-1.46	-4.10	-0.31
B36	-0.23	0.37	-0.93	-2.54	-11.20
B37	-0.29	0.15	0.16	4.33	-1.85
B38	0.12	-0.01	1.94	-3.69	2.55
B46	0.05	0.35	8.69	30.63	2.23
B47	0.19	-0.05	-1.04	-2.06	2.15
B48	-0.07	-0.12	-1.73	-8.42	-4.46
B67	-0.55	-0.42	-7.98	-17.81	-8.51
B68	0.73	-0.95	-5.09	-6.29	35.36
B78	0.29	0.16	4.43*	2.52	1.37

1/FPuT = Fruit pulp thickness (cm), FPeT = Fruit peel thickness (cm), TSS = Total soluble solid (%brix), Fn = Firmness (N) and PFP = Percentage of fruit pulp (%) **Note:** *: Significant at the 0.05 level and **: Significant at 0.01 level.

4.2.3 Heterosis of F_1 hybrids in green-fleshed galia melon

The heterosis (H) and heterobeltiosis (HB) of F_1 hybrids in green-fleshed galia melons, it was found the most had positive values for the fruit components and yield (Table 4.19), the details are as follows (Table 4.20 and Table 4.21).

Fruit weight: The analysis of variance for heterosis of F_1 hybrids, it was found the hybrids B47, B37 and B27 had positive and statistically high in heterosis values (35.18%, 26.33% and 25.50%, respectively).

Fruit width: The analysis of variance for heterosis of F_1 hybrids, it was found the hybrids B47 and B37 had positive and statistically high in heterosis values (10.94% and 4.70%, respectively).

Fruit length: The analysis of variance for heterosis of F_1 hybrids, it was found the hybrids B67, B37 and B18 had positive and statistically high in heterosis values (8.19%, 16.22% and 3.49%, respectively).

Fruit cavity width: The analysis of variance for heterosis of F_1 hybrids, it was found the hybrids B34 and B47 had positive and statistically high in heterosis values (13.58% and 8.53%, respectively). The hybrids B12 and B78 negative high in heterosis value (-28.32 and -14.26%, respectively).

Fruit cavity length: The analysis of variance for heterosis of F_1 hybrids, it was found the hybrids B17 and B67 had positive and statistically high in heterosis values (16.02% and 11.15%, respectively). The hybrids B12 has negative heterosis value (-29.26%).

Fruit pulp thickness: The analysis of variance for heterosis of F_1 hybrids, it was found the hybrids B23, B47 and B16 had positive and statistically high in heterosis values (19.07%, 15.25% and 8.07%, respectively).

Fruit peel thickness: The analysis of variance for heterosis of F_1 hybrids, it was found the hybrid B27, B17, B37 and B36 had positive and statistically high in heterosis values (81.82%, 150.70%, 126.08% and 78.72%, respectively).

TSS: The analysis of variance for heterosis of F_1 hybrids, it was found all hybrids had statistical nonsignificant for heterosis values.

Firmness: The analysis of variance for heterosis of F_1 hybrids, it was found the hybrids B37 and B46 had negative and statistically high in heterosis values (-28.31% and -15.25%, respectively).

Percentage of fruit pulp: The analysis of variance for heterosis of F_1 hybrids, it was found the hybrid B13 has positive and statistically high in heterosis values (5.99%).

4.2.4 Correlation between fruit composition and yield characteristics of orange-fleshed galia melon

Results of the correlation analysis between fruit and yield of green fleshed galia melons (Table 4.22). It was found that: **fruit weight** was correlated with fruit width (r=0.956), fruit length (r=0.854), fruit cavity width (r=0.159), fruit cavity length (r=0.812), fruit pulp thickness (r=0.724), fruit peel thickness (r=0.288) and percentage of pulp (r=0.130). There was non-correlation with sweetness (r=-0.077) and firmness (r=0.138). **Fruit width** was correlated with fruit length (r=0.803), fruit cavity width (r=0.198), fruit cavity length (r=0.757), fruit pulp thickness (r=0.700), fruit peel thickness (r=0.264), and firmness (r= 0.145). There was non-correlation with sweetness (r=-0.08) and percentage of pulp (r=0.062). **Fruit length** was correlated with fruit cavity length (r=0.884), fruit pulp thickness (r=0.668), fruit peel thickness (r=0.282), and percentage of pulp (r=0.189). There was non-correlation with fruit cavity width (r=-0.023), sweetness (r=-0.113), and firmness (r= 0.076). **Fruit cavity width** was correlated with percentage of pulp (r=-0.275). There was non-correlation with fruit cavity length (r=0.048), fruit pulp thickness (r=-0.068), fruit peel thickness (r=-0.025), sweetness (r=-0.061), and firmness (r=0.059). **Fruit cavity length** was correlated with fruit pulp thickness (r=0.529), fruit peel thickness (r=0.248), sweetness (r=-0.20) and firmness (r=0.147). There was non-correlation with percentage of pulp (r=0.04). **Fruit pulp thickness** was correlated with percentage of pulp (r=0.754). There was non-correlation with fruit peel thickness (r=0.072), sweetness (r=0.044), and firmness (r=-0.077). **Fruit peel thickness** was correlated with percentage of pulp (r=-0.142). There was non-correlation with sweetness (r=-0.047) and firmness (r=-0.05). **TSS (sweetness)** was correlated with firmness (r=-0.233) and percentage of pulp (r=0.143). **Firmness** non-correlation with percentage of pulp (r=-0.019) at 0.05 and 0.01 significance levels.

Table 4.19 Mean of parents, mean of F_1 hybrids, highest-lowest percentage of heterosis and the number of hybrids with positive or negative dominance in the fruit components and yield of orange-fleshed galia melon.

	[1/]FWe	FWi	FL	FCW	FCL	FPuT	FPeT	TSS	Fn	PFP
Parents average	0.99	11.88	13.26	5.37	8.20	2.61	0.38	14.00	29.76	43.84
Hybrid average	1.12	12.32	14.11	5.38	8.97	2.73	0.54	13.87	30.61	44.30
Heterosis										
% Lowest	-10.5	-21.18	-26.26	-28.32	-29.26	-16.45	12.31	-20.75	-32.45	-28.36
% Maximum	71.42	36.07	45.9	33.73	39.81	43.49	298.92	43.77	37.86	40.07
- hybrids	3	3	1	11	2	3	0	10	11	8
+ hybrids	18	18	20	10	19	18	21	11	10	13
Heterobeltiosis										
% Lowest	-10.34	-21.83	-23.79	-27.07	-25.66	-17.36	7.70	-18.07	-27.80	-27.27
% Maximum	70.77	20.18	29.73	30.61	29.77	25.05	292.79	22.85	33.09	21.08
- hybrids	3	3	1	11	2	3	0	10	12	8
+ hybrids	18	18	20	10	19	18	21	11	9	13

[1/]FWe = Fruit weight (kg), FWi = Fruit width (cm), FL = Fruit length (cm), FCW = Fruit cavity width (cm), FCL = Fruit cavity length (cm), FPuT = Fruit pulp thickness (cm), FPeT = Fruit peel thickness (cm), TSS = Total soluble solid (%brix), Fn = Firmness (N) and PFP = Percentage of fruit pulp (%).

Table 4.20 Estimates of heterosis (H) percentage and heterobeltiosis (HB) percentage for fruit weight, fruit width, fruit length, fruit cavity width and fruit cavity length in orange-fleshed galia melon.

Hybrids/ genotype	[1/]FWe		FWi		FL		FCW		FCL	
	[2/]H	HB	H	HB	H	HB	H	HB	H	HB
B12	-1.47	-5.45	-21.18	-21.83	-26.26	-23.79	-28.32	-27.07	-29.26	-25.66
B13	36.43	35.02	12.53	12.10	5.31	5.08	4.90	4.74	-4.16	-4.21
B14	25.46	23.71	9.65	9.36	5.95	5.58	7.08	6.63	6.98	5.64
B16	10.29	7.31	5.60	4.78	4.27	3.89	-3.88	-3.76	2.96	2.72
B17	28.37	23.31	9.41	8.39	14.12	13.29	-3.05	-3.04	16.02*	15.03*
B18	12.48	10.18	8.82	7.96	3.49*	3.33**	4.48	4.17	2.46	2.37
B23	29.32	28.62	6.88	6.87	9.78	9.43	-4.51	-4.52	4.64	3.76
B24	23.05	16.71	7.56	6.80	8.41	6.81	33.73	30.61	13.74	10.46
B26	11.43	10.12	2.37	2.31	0.21	0.18	-3.02	-2.82	5.04	4.65
B27	25.50*	23.62	6.41	6.25	4.31	3.92	-1.26	-1.33	1.62	1.52
B28	24.19	21.56	6.10	5.96	11.33	10.02	6.87	6.58	18.90	15.73
B34	71.42	70.77	16.05	15.96	18.33	18.16	13.58**	13.58**	29.91	29.77
B36	-10.50	-10.34	-6.36	-6.32	1.82	1.79	-13.02	-12.96	1.59	1.44
B37	26.33*	25.95*	4.70**	4.69**	16.22*	16.11*	-14.68	-14.44	10.65	10.12
B38	41.32	29.69	36.07	20.18	45.90	29.73	17.33	8.29	39.81	24.87
B46	9.13	6.70	3.50	3.11	8.53	7.38	2.67	2.40	12.09	9.72
B47	35.18*	26.44*	10.94**	9.91**	15.32*	13.67*	8.53*	7.80*	18.28	14.86
B48	8.15	6.91	0.69	0.68	6.28	5.80	-4.81	-4.20	14.85	13.06
B67	7.29	6.52	0.74	0.71	8.19**	7.84**	-4.97	-4.71	11.15*	10.78*
B68	8.69	6.97	1.00	0.87	4.39	3.48	7.72	7.25	13.28	11.06
B78	-1.68	-1.40	-3.42	-3.35	5.84	5.62	-14.26	-13.42	12.20	11.10

[1/]FWe = Fruit weight (kg), FWi = Fruit width (cm), FL = Fruit length (cm), FCW = Fruit cavity width (cm) and FCL = Fruit cavity length (cm).

[2/]H = % of heterosis and HB = % of heterobetiosis.

Note: *: Significant at the 0.05 level and **: Significant at 0.01 level.

Table 4.21 Heterosis percentage (H) and heterobeltiosis percentage (HB) for fruit pulp thickness, fruit peel thickness, sweetness, firmness, and percentage of fruit pulp in orange-fleshed galia melon.

Hybrids/ genotype	[1]/FPuT		FPeT		TSS		Fn		PFP	
	[2]/H	HB	H	HB	H	HB	H	HB	H	HB
B12	-16.45	-17.36	29.26	7.70	-20.75	-18.07	2.77	2.38	-28.36	-27.27
B13	18.43	17.11	107.57	101.96	-3.60	-3.64	5.63	5.63	5.99*	5.64*
B14	18.06	16.46	102.93	81.18	-4.88	-4.58	-29.85	-27.54	7.97	7.36
B16	8.07*	6.25	98.92	71.98**	-0.48	-0.43	0.74	0.99	2.69	2.19
B17	7.23	5.76	150.70*	107.72*	-3.84	-3.27	-2.62	-3.44	-1.68	-2.00
B18	1.12	0.72	83.84	59.53	2.52	2.47	-7.56	-4.74	-6.21	-6.28
B23	19.07*	18.78*	14.40	13.86	21.91	21.32	22.18	22.18	11.44	11.33
B24	3.12	2.70	68.10	54.93	8.81	7.15	-7.70	-7.12	-3.49	-3.35
B26	1.02	1.13	72.74	66.03	11.51	9.97	12.27	11.62	-1.14	-1.01
B27	6.25	6.04	81.82**	73.85**	19.85	18.97	37.86	33.09	0.35	0.47
B28	2.90	2.83	22.04	20.57	7.36	6.61	10.42	8.34	-2.93	-2.83
B34	23.47	23.72	298.92	292.79	-9.59	-9.43	-3.03	-3.03	6.38	6.55
B36	-7.54	-7.35	78.72*	76.07*	-5.14	-5.14	4.65	4.17	-1.33	-1.08
B37	13.43	13.23	126.08*	120.77	13.50	13.29	-28.31*	-27.80*	8.53	8.51
B38	43.49	25.05	73.03	51.76	43.77	22.85	9.29	-1.24	40.07	21.08
B46	10.34	9.18	26.24	17.12	-7.61	-7.02	-15.25*	-15.02*	6.72	6.61
B47	15.25*	13.86*	44.11	34.00	1.68	1.41	-32.45	-24.90	3.87	3.75
B48	5.74	5.03	12.31	8.24	7.85	6.92	-15.64	-11.20	5.40	5.17
B67	1.22	1.19	93.25	81.91	1.53	1.40	-9.31	-7.20	0.55	0.56
B68	-0.66	-0.64	15.29	13.00	-4.30	-4.05	-7.22	-5.58	-1.81	-1.76
B78	0.35	0.40	21.79	21.11	-7.24	-6.84	5.44	4.90	3.87	3.84

[1]/FPuT = Fruit pulp thickness (cm), FPeT = Fruit peel thickness (cm), TSS = Total soluble solid (%brix), Fn = Firmness (N) and PFP = Percentage of fruit pulp (%).

[2]/H = % of heterosis and HB = % of heterobetiosis.

Note: *: Significant at the 0.05 level and **: Significant at 0.01 level.

Table 4.22 The correlation coefficient of fruit components and yield characteristics in orange-fleshed galia melon.

Correlations									
	Fruit width	Fruit length	Fruit cavity width	Fruit cavity length	Fruit pulp thickness	Fruit peel thickness	TSS	Firmness	%Pulp
Fruit weight	0.956**	0.854**	0.159*	0.812**	0.724**	0.288**	-0.077	0.138	0.130*
Fruit width		0.803**	0.198**	0.757**	0.700**	0.264**	-0.080	0.145*	0.062
Fruit length			-0.023	0.884**	0.668**	0.282**	-0.113	0.076	0.189**
Fruit cavity width				0.048	-0.068	-0.025	-0.061	0.059	-0.275**
Fruit cavity length					0.529**	0.248**	-0.200**	0.147*	0.040
Fruit pulp thickness						0.072	0.044	0.077	0.754**
Fruit peel thickness							-0.047	-0.050	-0.142*
TSS								-0.233**	0.143*
Firmness									-0.019

Note: *: Significant at the 0.05 level and **: Significant at 0.01 level.

CHAPTER V

CONCLUSION AND DISCUSSION

5.1 The inbred line selection from F_3 plants to F_6 plants of 2 types galia melon

The study selection of parental to selected parental (Table 4.1), found that 5 parentals of green-fleshed galia melon (GG), 7 parentals of orange-fleshed galia melon (GO). It was different genotypes were shape, peel color, pulp color and percentage of mesh. The different genotype, which is good in terms of breeding program. The nature of the plant to be breed, propagation mating, characteristics genetic diversity and relevant genetic information such as qualitative or quantitative characteristics and heterosis. This information will be helpful in making informed plant breeding decisions and effective to achieve the objectives (Kankaew, 2011).

5.2 The study combing ability test, heterosis of F_1 hybrids

5.2.1 Green-fleshed galia melon (GG)

The combining ability test was using half diallel cross method, followed Griffing's Method 2 Model 1 (Griffing, 1956), which seeds of F_5 seeds in selected. For green-fleshed galia melon (GG) gave 10 hybrids and planted compare 5 parentals. The experiment plan used the completely randomized design (CRD). There were 3 replications and 3 plants per replication. From analysis of variance of mean in fruit and yield component characteristics, found that the genotype, the comparison among the parent lines, the comparison among the hybrids and the class comparisons between parent lines and hybrids. There was statistically significant difference in commercially important characteristics. When comparing the GCA : SCA ratio, found that the positive gene effect with more important than the negative gene influence in all characteristics studied. This is consistent with the study of El-Eslamboly (2018). From analysis variance, found that the lines A3 and A4 had low fruit cavity length. In addition, the lines A1, A2 and A5 had the best parent, especially A2 line had good characteristics such as fruit weight, fruit length and fruit pulp thickness. That, there were corresponds to GCA, found that the line A2 has high GCA values of important characteristics. The estimates of SCA in F_1 hybrids, found that the hybrids A12, A14, A23 and A24 had high SCA values, corresponds to heterosis values, these hybrids had high heterosis values for important characteristics. This hybrid can be used to develop into a hybrid in the future (Figure 5.1).

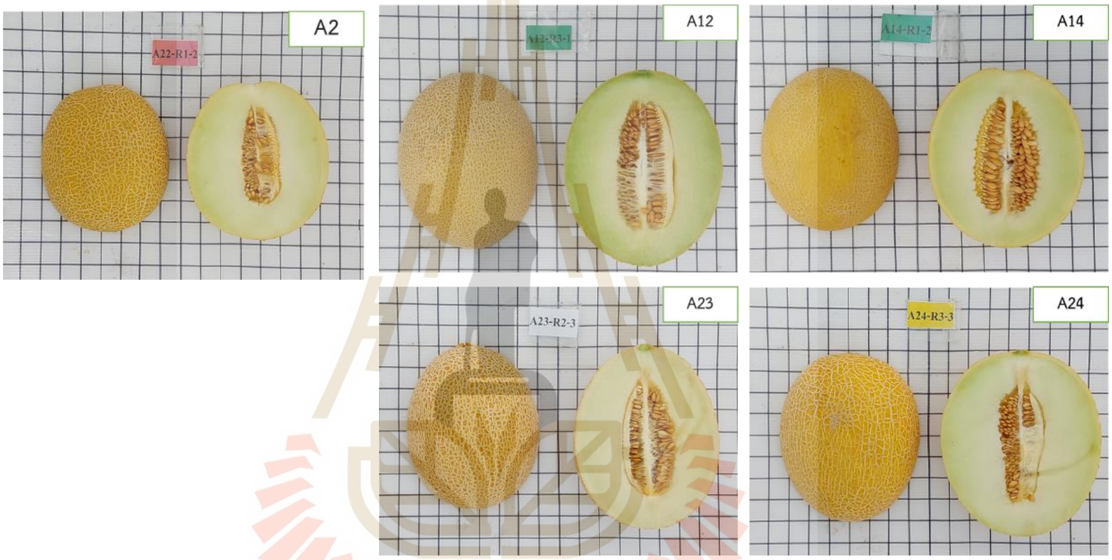

Figure 5.1 The parent line was high GCA and F_1 hybrids were high SCA and heterosis for important characteristics of fruit in green-fleshed galia melon.

5.2.2 Orange-fleshed galia melon (GO)

The combining ability test was using half diallel cross method, followed Griffing's Method 2 Model 1 (Griffing, 1956), which seeds of F_5 seeds in selected. For orange-fleshed galia melon (GO) gave 21 hybrids and planted compare 7 parentals. The experiment plan uses the completely randomized design (CRD). There were 3 replications and 3 plants per replication. From analysis of variance of mean in fruit and yield component characteristics, found that the genotype, the comparison among the parent lines, the comparison among the hybrids and the class comparisons between parent lines and hybrids. There was statistically significant difference in commercially important characteristics. When comparing the GCA:SCA ratio, found that the positive gene effect with more important than the negative gene influence in all characteristics studied. This is consistent with the study of El-Eslamboly (2018). From analysis variance, found that the line B4 has high sweetness and low fruit cavity length. In addition, the lines B2, B3, B4, B6 and B8 especially B2 line had good characteristics such as fruit weight, fruit width, fruit length, firmness, and percentage of pulp. That, there were corresponds to GCA, found that the line B2 and B3 had high GCA values of important characteristics. The estimates of SCA in F_1 hybrids, found that the hybrids B18 and B34 had negative SCA values of fruit cavity length, which mean was thin peel of fruit. The hybrid B12, B27 and B78 had high SCA values in percentage of pulp and sweetness, corresponds to heterosis values, these hybrids had high heterosis values for important characteristics. This hybrid can be used to develop into a hybrid in the future (Figure 5.2).

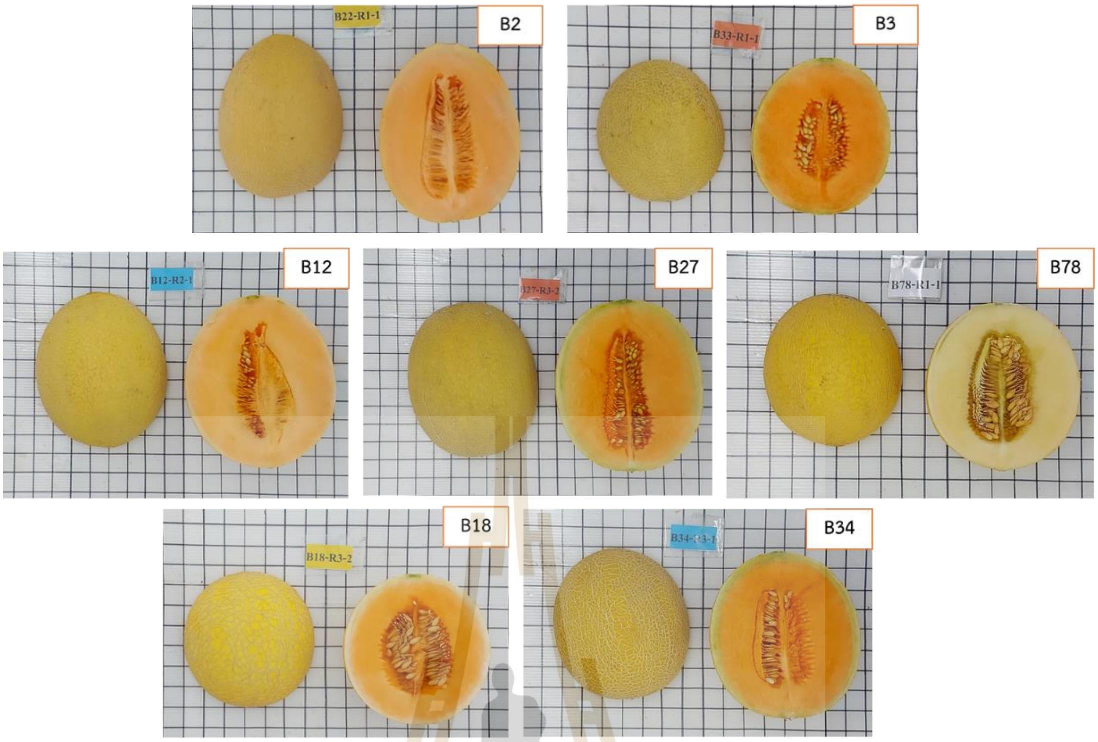

Figure 5.2 The parent lines were high GCA and F_1 hybrids were high SCA and heterosis for important characteristics of fruit in orange-fleshed galia melon.

The results were consistent with the study of Pathet (2006) study the heterosis between 2 varieties of cantaloupe, it was found that yield per plant gave a heterosis value of 12.71%, and total yield per plant gave a heterosis value of 8.20%. Showing that the hybrid between 2 varieties of cantaloupe gave yield per plant had high heterobeltiosis, and the total yield per plant was high heterosis. The last, Pidkwamlub (2014), they was study about inbred line selection in the hybrid glutinous rice corn improvement project and genetic testing, which selecting population by S_1 selection: (1) half - sib (HS), (2) full - sib (FS), and (3) S_1- progeny test (S_1); this method was able to select S_2 population with good agricultural potential The later, Kamer (2015) studies was the hybrid vigor, heritability, inbreeding depression, number of gene pairs were valued for fruit characters and yield in melon. They used half diallel mating system to obtain 10 hybrids combinations. The results revealed the hybrid were significant with positive heterosis and heterobelosis for all character. The later, Khanobdee (2016) study improvement of long fruit hybrid cucumber (*Cucumis sativus* L.) for resistance to downy mildew on increasing productivity and reducing the cost of chemicals used two methods of combined ability test follow Griffing's method I. From diallel cross showed moderate resistance to downy mildew, stable stability with a high negative SCA of downy mildew resistance and positive SCA of fruit length. The last, Pornsuriya (2016) study was to estimate heterosis for fruit characters and yield in the inter-varietal hybrids of oriental sweet melon. They were used a half diallel cross. The results, where significant variety effect was observed for all characters. Heterosis effect was significant for fruit weight, fruit width, fruit shape index and yield. Overall heterosis partitioned into components showed that average heterosis and variety heterosis were significant for fruit width and fruit shape index. Specific heterosis was significant for fruit weight, fruit width, fruit shape index and yield. The last, Pornsuriya (2018) study the yield performance and heterosis for yield of crosses between Thai melon lines and cantaloupe testers was determined involving 4 Thai melon lines (L1, L2, L3 and L4) and 3 cantaloupe testers (cantaloupe populations: T1, T2 and T3). The results revealed that parents and crosses were significantly different in yield. The hybrid gave the highest yield, and significantly positive heterosis and significantly positive heterobeltiosis.

5.3 The study correlation between fruit component and yield characteristics

5.3.1 Green-fleshed galia melon (GG)

The study correlation was studied between weight characteristics, fruit width, fruit length, fruit cavity width, fruit cavity length, fruit pulp thickness, fruit peel thickness, sweetness, firmness. and percentage of pulp. It was found that fruit weight, fruit length and fruit cavity length. There was a positive correlation with all characteristics. Fruit width and fruit pulp thickness characteristics were positively correlated with all characteristics and except for the firmness. Fruit cavity width characteristic was positively correlated with all characteristics and except for the appearance of the thickness of the peel and the sweetness. Sweetness characteristic was negatively correlated with firmness and percentage of pulp. The firmness characteristics, there was a negative correlation with the percentage of pulp.

5.3.2 Orange-fleshed galia melon (GO)

The study of correlation was studied between weight characteristics, fruit width, fruit length, fruit cavity width, fruit cavity length, fruit pulp thickness, fruit peel thickness, sweetness, firmness, and percentage of pulp. It was found that fruit weight and fruit width were positively correlated with all characteristics, except the sweetness. Fruit pulp thickness was positively correlated with all characteristics studied. Fruit length correlated with fruit cavity length, fruit peel thickness and percentage of pulp, but there was a negative correlation with fruit cavity width and sweetness. Fruit pulp thickness was positively correlated with percentage of pulp. The results were consistent with the study of Iathet (2006) studies was correlations of fruit characters and yield in of Thai melon. They are with two inbred lines (RM1 and LM2) of slicing melon. The results revealed the fruit width correlated negatively with fruit length and the result shape index. Fruit shape and fruit size did not correlate with fruit number per plant and yield. While the number of fruits per plant had a high positive correlation with the yield per plant. Shows that correlations between traits can be used to help improve plant varieties. Indirect selection may be conducted in multiple characteristics or in multiple characteristics at the same time. Using data from correlated studies. The last, Pak J Biol Sci. (2013) study was genotypic correlation and path analyses were carried out for growth, yield, and fruit quality traits in 13 sweet melon genotypes collected from different places in Egypt. They were study the correlation at under irrigated conditions. The results revealed the total yield per plant was positively and significantly correlated with fruit weight, flesh fruit thickness and fruit length. Positive direct effects were exhibited for fruit weight, number of fruits per plant and stem length on total yield per plant, while maximum positive indirect effects on total yield per plant were exhibited by fruit length and flesh fruit thickness through fruit weight.

Recommendation

1. Planting test lines in this research, that just only one location and one season. It's recommended to test plants at 3 locations and 3 seasons for consistent strain.

2. Conclusion tend to have high yields; this hybrid can be developed into a hybrid breeding further.

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APPENDIX

A

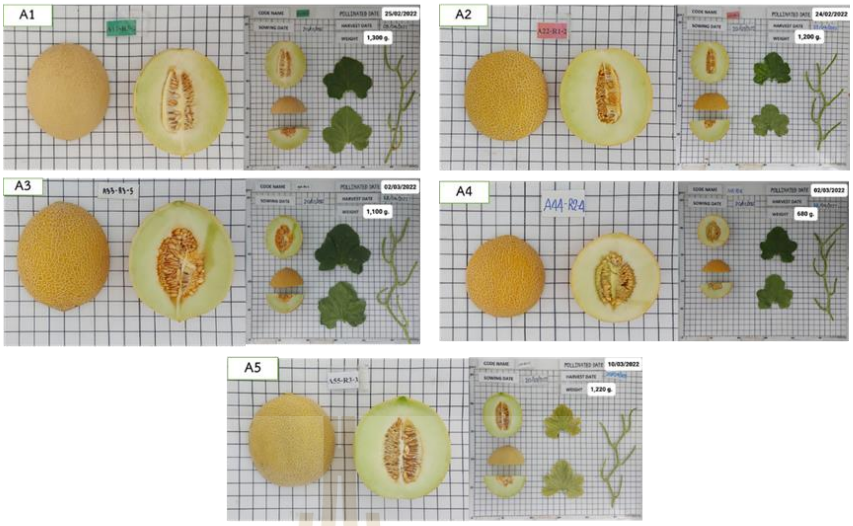

Figure 1 The 5 Inbreed lines of green-fleshed galia melon.

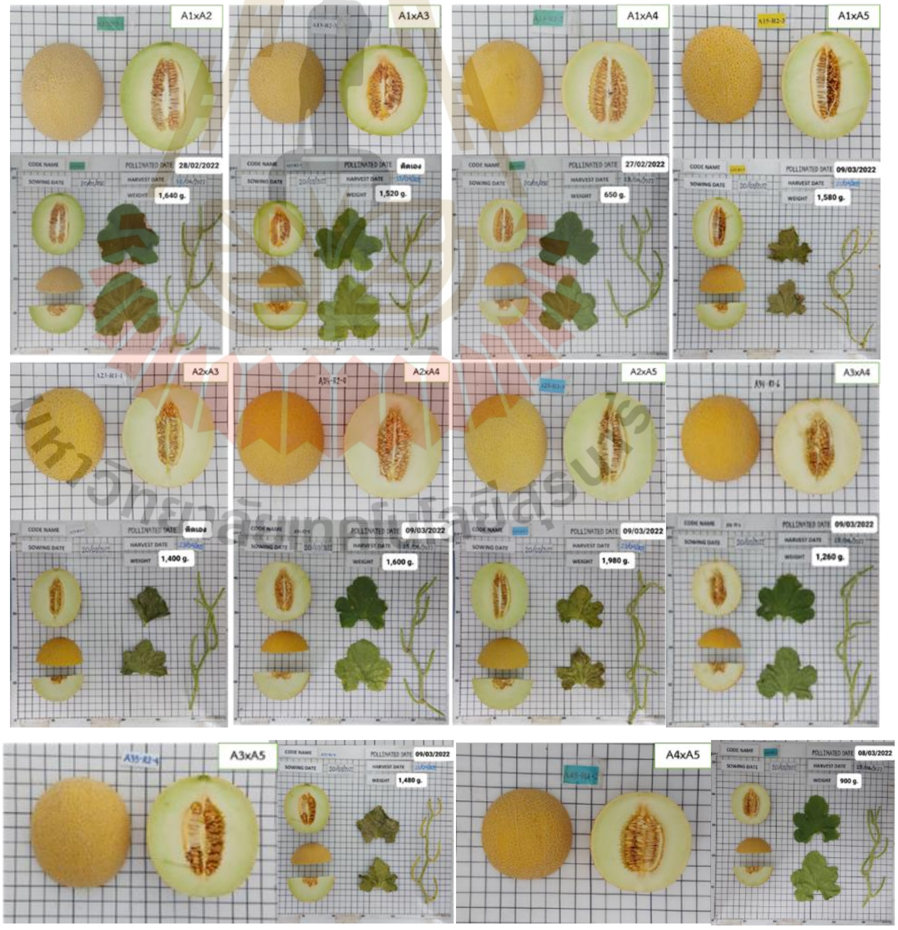

Figure 2 The hybrid A12, A13, A14, A15 A23, A24, A25, A34, A35 and A45

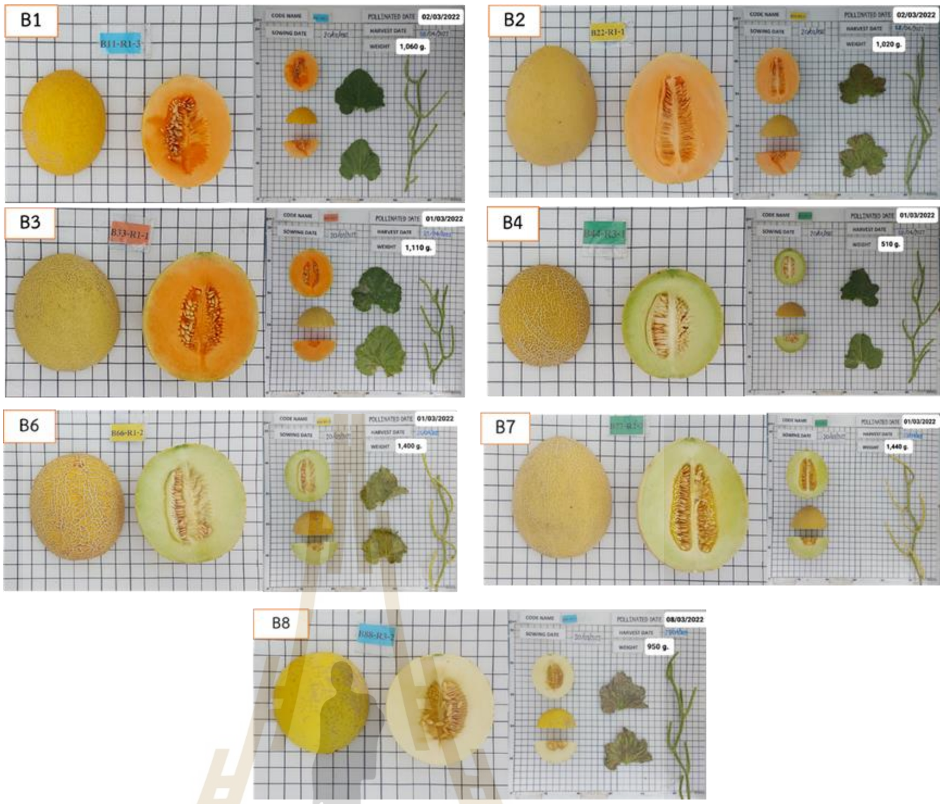

Figure 3 The 7 Inbreed lines of orange-fleshed galia melon.

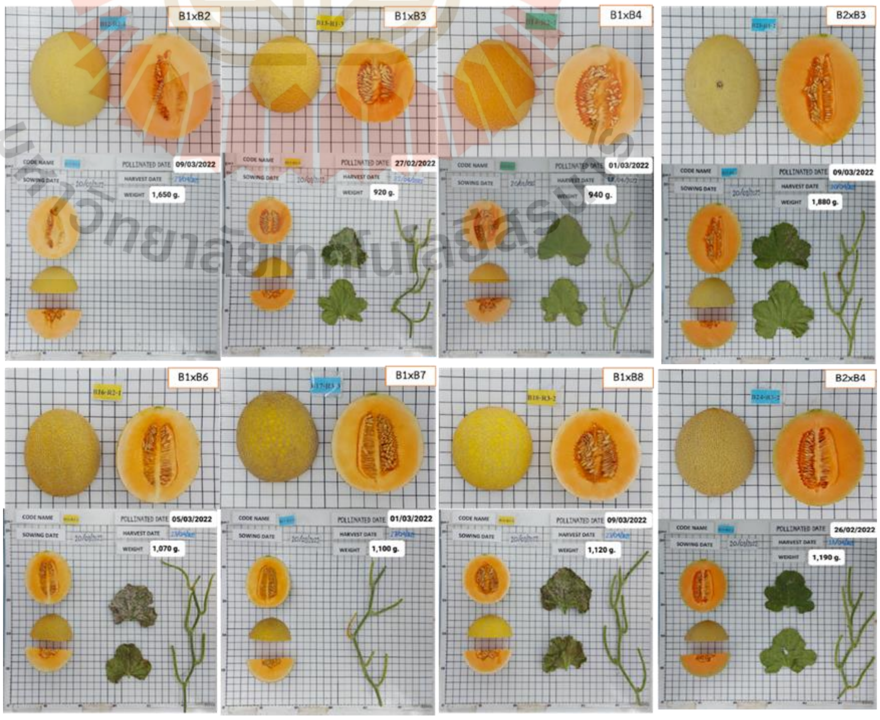

Figure 4 The hybrids B12, B13, B14, B16, B17, B23 and B24

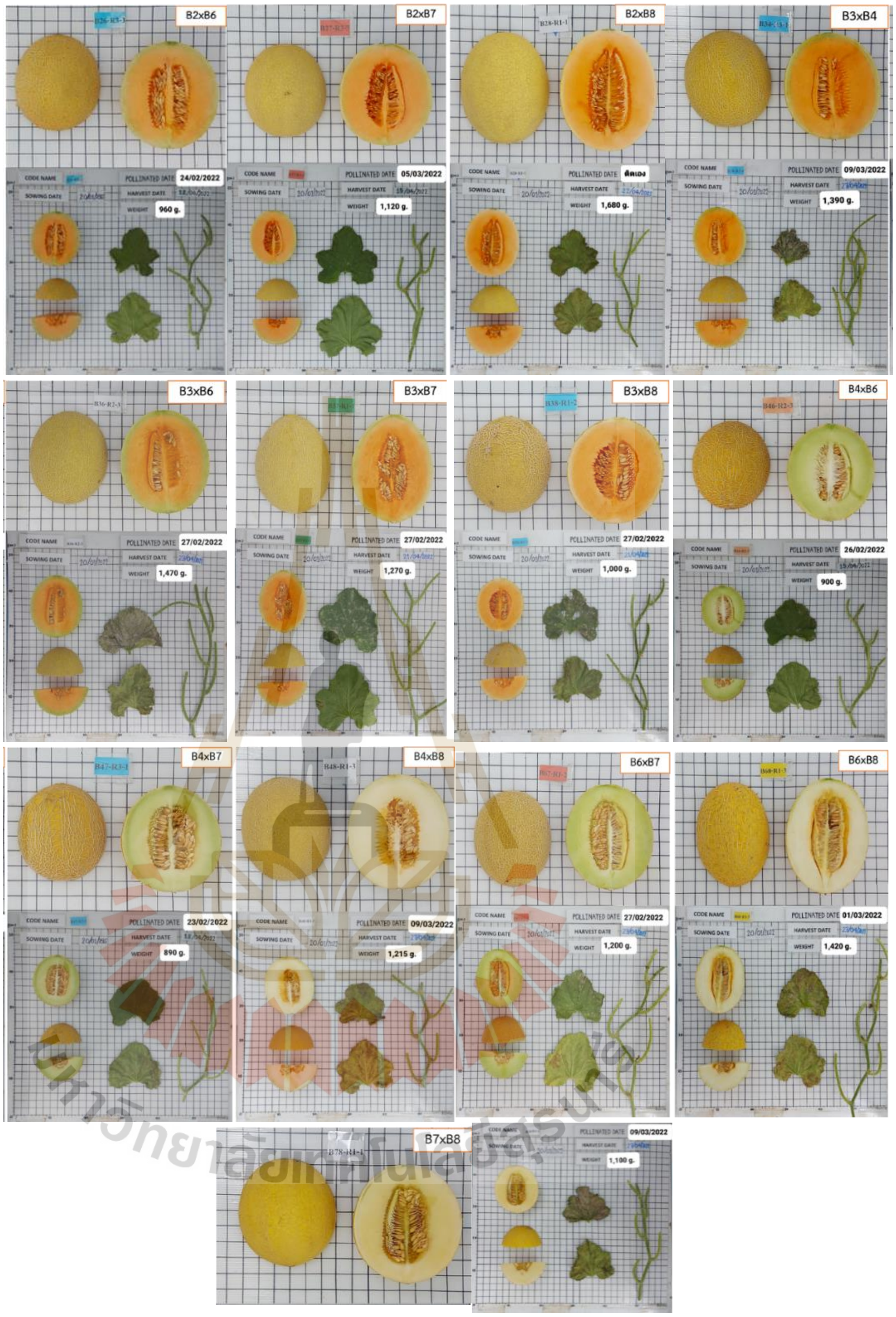

Figure 5 The hybrids B26, B27, B28, B34, B36, B37, B38, B46, B47, B48, B67, B68 and B78

BIOGRAPHY

Miss Jiraporn Jenwithee was born on 12 July 1992 in Sikhio District, Nakhon Ratchasima Province. In 2003-2010, she attended and graduated high school from School Sikhio "Sawat Phadung Witthaya", Nakhon Ratchasima Province. In 2011-2013, she attended a bachelor's degree, Department of Crop Production of Technology, School of Agricultural of Technology, Suranaree University of Technology. Graduated with a Bachelor of Science degree (Crop production of Technology). In 2016, she passed the cooperative education practice at Green World Genetics (Thailand) Co., Ltd. as an assistant breeder. In 2017, she entered a master's degree program Department of Crop Production of Technology, School of Agricultural of Technology, Suranaree University of Technology, as well working teaching assistant in the field of crop production technology.