

STUDIES ON COMBINING ABILITY AND CORRELATION IN MELON (*Cucumis melo* L.)

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ABSTRACT: *This study was carried out during two summer seasons; i.e., 2006 and 2007 to investigate the general and specific combining abilities (GCA and SCA) and correlation in melon at Barrage Experimental Station of Hort. Res. Institute. Five parental inbred lines viz., Helpest, Zentei, Queen, Golden Star and Tetenyi cseresheju were used in the study. In 2006 the parental lines were planted in the field during summer season, all possible crosses, without reciprocals, were made to produce the F_1 s. In 2007, F_1 and the parents were evaluated for some characters. The data of this study was to determine the different types of gene effects in terms of general and specific combining abilities (GCA and SCA), in addition to correlation regarding some characters, i.e., days to fruit maturity, average fruit weight, nodes to first female flower appearance appearance, sex ratio, yield / plant and total soluble solids (TSS%). The results indicated that genes with additive and non-additive effects are involved in the inheritance of all studied traits. The estimated ratio between GCA and SCA mean squares suggested that the additive gene effects have the main role in the inheritance of these traits except the nodes of first female flower appearance and sex ratio, indicating that the dominance genetic variance was more important than the additive one for the two traits. Obtained values of GCA for the studied characters in each of the studied parental cultivars showed that Helpest and Zentei cvs. are the best of all since they showed significant GCA values for all studied traits. A critical examination of data obtained on SCA effects for F_1 hybrids showed that the best hybrids were "Helpest \times Queen" and "Zentei \times Queen", since they showed significant SCA effect values for all studied traits, followed by the crosses "Helpest \times Zentei", "Zentei \times Gloden Star" and "Zentei \times Tetetenyi cserecheju", since they showed significant SCA effect values for most evaluated characters. Accordingly, these superior and prospective materials can be used in melon improvement through breeding programmes. Significant positive correlations were found between some pairs of the studied traits. Meanwhile, significant negative correlations were reflected between the some pairs of the trait.*

Key Words: *additive and non-additive gene effects, combining ability, correlation.*

INTRODUCTION

Melon (*Cucumis melo* L.) is an important summer vegetable crop in most countries. In Egypt, the cultivated area of melon in 2007 according to statistics of the Ministry of Agriculture, reached about 102777 feddans, and its production reached nearly 1055003 tons with an average of 10.150 tons/fed.

Assessment of nature and magnitude of the genetic effects and correlation in the traits are essentially important in designing the appreciate breeding programme.

Many investigations were conducted on the combining ability in melon for days to maturity. Darwish (1986), Maiero *et al.*, (1987), Kitroonguang *et al.*, (1992) and Hatem *et al* (1995) studied diallel analysis in melon and reported that GCA was greater than SCA for days to fruit maturity, suggesting that additive variance was more important than the non-additive one in inheritance of this trait .

Darwish (1986) and El-Mighawry (1998) found that the variance associated with GCA ad SCA effects were highly significant for average fruit weight. They added that the mean squares for GCA were much higher if compared with those of SCA, indicating that the additive genetic variance was more important in inheritance of this trait.

Rakhi and Rajamony (2005) studied the variability, heritability and genetic advance in landraces of culinary melon (*C. melo* L.) and found that genotypic and phenotypic coefficients of variation were high for yield per plant followed by the fruit weight. They added that node of first female flower appearance ranged from 6-12 with heritability to 73.22% and sex ratio ranged from 9.89 – 38.15 with heritability to 82.76% in culinary melon.

Several studies were conducted on the GCA and SCA effects for total yield as fruit weight in melon. Maiero *et al.*, (1987), Om *et al.*, (1987) and El-Mighawry (1998), showed that GCA was greater than SCA for these traits, suggesting that additive variance was more important than the non-additive.

The inheritance of TSS content in melon was studied by Sachan and Nath (1977), Thomas and Davis (1984), El-Mighawry (1998) and Glala *et al.*, (2002), they reported that the GCA and SCA effects were significant for TSS, and GCA was greater than SCA, suggesting that the additive variance was more important than the non-additive.

Phenotypic and genotypic correlation among the economic characters in melon were studied by several investigators. Abd-El-Moneam (1976), El-Doweny (1985), and Kirtoonguang *et al.*, (1992) reported that correlation between the performance of parents and the average of their hybrids in melon were positive in most cases except vine length.

Glala *et al.*, (2002) and Jose *et al.* (2005) reported that correlation analysis revealed that there were positive and significant correlations between main stem length, with number of leaves, total fresh and dry weight of plant. Moreover, there was a significant positive correlation between maturity

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period, and number of days from transplanting to harvesting. Also, a positive correlation was found between early, total and marketable yield, with number of leaves, total fresh and dry weight of plant and number of fruits per plant. Meanwhile, there were negative and significant correlations between number of days from transplanting to flowering, with maturity period, early yield and number of fruits per plant.

Therefore, this study was conducted to determine the different types of gene actions (general and specific combining abilities) by evaluating a diallel cross mating design in melon, and correlation between some traits.

MATERIALS AND METHODS

The present investigation was carried out at the Experimental farm of Hort. Res. Station, El-Kanater El-Khyria during two successive summer seasons of 2006 and 2007. Five parental lines of melon (*C. melo*) were used in this study, viz, Helpest (HE), Zentei (ZE), Queen (QU), Golden Star (GS) and Tetenyi csereshju (TC), belong to *C. melo* var. *reticulates* and were obtained from Sargadinnya, Hungary. These parental lines were at a high degree of homozygosity since they were previously selfed for two generations.

The main characteristics of these parental lines are shown in Table (1).

Table (1): Main characteristics of the parental lines.

Parental lines	Mean characters	
	Plants	Fruits and flesh
1- Helpest (HE)	Prolific and productive vine.	Round, heavily netted and lightly ribbed, weight (1 – 1.250kg) Pale orange, very thick and firm, excellent flavor.
2- Zentei (ZE)	Vigorous and productive vine	Slightly elongated, medium sized (0.750 – 1.200kg). Rind is heavily netted and ribbed. Pink orange flesh, very thick with good flavor and sweetness.
3- Queen (QU)	Vigorous vine	Round, strongly netted with slight ribbing. Its weight up to 1.5kg. Salmon colored flesh, flesh is firm.
4-Golden Star (GS)	Strong, vigorous vine	Slightly ribbed, well netted, round and weight 1.1kg. Salmon orange flesh, firm flesh and sweet.
5-Tetenyi csereshju (TC)	Strong vine	Well netted with slight ribbing, rind is hard. Nearly round are shape, Salmon color and medium thick, weighing up to 1.00kg.

In the summer season of 2006, the five parents were planted in the field and all possible crosses, without reciprocals, were made to generate the experimental materials (F_1 combinations).

The 15 entries viz, 5 parents and 10 F₁ hybrids, were planted in 2007 summer season in the field on March 7th for measuring the different types of genes effects in the terms of the general and specific combining abilities (GCA and SCA) in melon and correlation coefficient regarding some plant and fruit traits. A randomized complete block design with three replicates was adopted. Each plot contained two rows each of 5.0 m. long and 1.20 m. wide ten plants were grown in each row. The standard cultural practices were applied in the two experimental seasons.

The studied characters were:

1. Days to fruit maturity: It was determined as number of days from sowing to first fruit maturity (as the mean of all plants for each replicate).
2. Average fruit weight (kg.): It was measured by dividing the total weight of fruits by their total number.
3. Nodes to first female flower appearance: as mean of all plants for each replicate.
4. Sex ratio: It was determined for three plants from each replicate in each genotype, (number of male flowers/number of female flower appearances).
5. Total yield as fruit weight (kg.) per plant in all harvests.
6. Total soluble solids (TSS %) was determined as percentage using a hand refractometer.

Statistical procedures:

- 1-Analysis of variance was made in order to test the significant of the differences among the means of tested populations as shown by Cochran and Cox (1957). Differences among means for all characters were tested for significant according to the least significance differences (L.S.D.).
- 2-The analysis of general and specific combining abilities was done according to method (2) model (1) of Griffing (1956).
- 3-The relationships between some traits were determined by estimating the correlation coefficients (Snedecor, 1962).

RESULTS AND DISCUSSION:

[I]- Combining ability:

General and specific combining abilities were measured to determine the additive and non-additive gene effects for the studied traits. The analysis of variance for GCA and SCA for the studied characters is given in Table (2). The variances associated with both GCA and SCA were highly significant for all traits. This result suggests that genes with additive and non additive effects are involved in the inheritance of these characters. The ratio between the mean squares of GCA and SCA showed that the additive component of genetic variance played the main role in the inheritance of all studied traits, except nodes of first female flower appearance and sex ratio. The ratio between GCA and SCA for the two traits were 0.562 and 0.719, respectively, suggesting that they ones controlled by dominant and epistatic gene effects.

These results confirm those reported by Darwish (1989), Maiero et al., (1987) Hatem (1992), El-Mighawry (1998), and Glala et al., (2002).

1- General combining ability (GCA):

highly significant negative GCA effects were shown by the cultivars Helpst (HE), Zentei (ZE) and Tetenyi csereshju (TC) for days to fruit maturity. Their GCA estimated values were (-1.948, -1.645 and -1.836, respectively). Also for node of the first female flower appearance GCA was estimated as -1.921, -1.802 and -1.929, respectively. These results suggest that these three parental lines could be considered as the best combiners and may be processing genes for early maturity, Table (3). On the other hand, the parents Queen (QU) and Golden Star (GS) showed positive effects with 0.931 and 4.498, respectively, for the days to the fruit maturity, and values were 2.531 and 3.121, respectively, for the node of the first female flower appearance. These parental lines may be processing genes for late maturity.

Regarding the average fruit weight, estimated GCA effects showed that the two parents HE and ZE gave significant negative GCA values (-1.771 and -1.439, respectively). On the other hand, significant positive GCA effects was shown by QU and GS (2.120 and 1.825, respectively), for light average fruit weight.

Two parental lines HE and ZE reflected the highest GCA effects (3.213 and 3.625, respectively), while, the lowest GCA effect values (-3.104, -0.935 and -2.799) were given by parental lines QU, GA and TC, respectively, for sex ratio.

Three lines viz, HE, ZE and TC showed significant positive GCA values (2.335, 2.692 and 1.453, respectively) for the total yield. Meanwhile, the other parental lines gave significant negative GCA effects values for this trait, (Table 3).

Examination of GCA effect values illustrated in Table (3) show that the three parental lines HE, ZE and GS are the best combiners for breeding to TSS content. They showed the highest values (1.834, 1.793 and 1.801 respectively). On the other hand, the other parents are the poorest combiners for breeding to high TSS content, since they exhibited negative values (-2.406 and -3.022) for parents QU and TS, respectively, as shown in Table (3).

In general, the parental lines Helpst (HE) and Zentei (ZE) were the best general combiners of the parents, since they showed significant GCA values for most of studied characters. The two parental lines exhibited high effects for all traits, (except the average fruit weight).

Table (2): Mean squares for combining ability (GCA and SCA) for some characters in melon.

Source of variation	Characters		Days to fruit maturity		Average fruit weight		Nodes to first female flower appearance		Sex ratio		Total yield as fruit weight/plant		Total soluble solids (TSS %)	
	MS	F	MS	F	MS	F	MS	F	MS	F	MS	F		
GCA	23.517	6.352**	2.153	11.331**	13.654	9.335**	3.751	7.205**	63.521	16.325**	14.695	7.212**		
SCA	3.552	2.835**	0.362	3.502**	24.302	19.271**	5.225	12.333**	10.325	5.261**	3.124	3.552**		
GCA/SCA	6.621		5.948		0.562		0.719		6.152		4.704			

** Significant at the 0.01 level of probability according to " T " test.

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Table (3): Estimated general combining ability (GCA) effects for the parental lines regarding some characters in melon.

Characters Parents	Days to fruit maturity	Average fruit weight	Nodes to first female flower appearance	Sex ratio	Total yield as fruit weight/plant	Total soluble solids (TSS %)
Helpest (HE)	-1.948**	-1.771*	-1.921**	3.213**	2.335**	1.834**
Zentei (ZE)	-1.645**	-1.439*	-1.802**	3.625**	2.692**	1.793**
Queen (QU)	0.931*	2.120**	2.531**	-3.104**	-3.657**	-2.406**
Golden Star (GS)	4.498**	1.825**	3.121**	-0.935*	-2.823**	1.801**
Tetenyi cersheju(TC)	-1.836**	-0.735	-1.929**	-2.799**	1.453*	-3.022**

* Significant at the 0.05 level of probability according to " T " test.

** Significant at the 0.01 level of probability according to " T " test.

2- Specific combining ability (SCA):

Regarding days to fruit maturity, the combinations "HE × ZE", "HE × QU", "HE × TC", "ZE × QU", "ZE × GS", "ZE × TC" and "QU × TC" showed significant negative SCA values (-2.98, -3.51, -0.99, -3.01, -1.02, -0.97 and -0.95, respectively), Table (4). These results suggest that these hybrids are good combinations for early maturity. Concerning average fruit weight, five crosses viz, "HE × QU", "HE × TC", "ZE × OU", "QU × GS" and "QU × TC" showed significant positive SCA values (0.92, 0.91, 0.98, 0.86 and 1.21, respectively). These results suggest that these hybrids are good combinations for high weight.

With respect to node of the first female flower appearance, seven hybrids, viz, "HE × ZE", "HE × QU", "HE × GS", "ZE × QU", "ZE × GS", "ZE × TC" and "QU × GS" showed significant negative SCA values (-0.94, -0.83, -1.25, -2.78, -1.55, -3.00 and -1.03, respectively), indicating that these crosses are the best combinations concerning for this trait.

Of the studied 10 F₁ hybrids, the crosses "HE × ZE", "HE × QU", "HE × GS", "ZE × QU", "ZE × GS", "ZE × TC", "QU × GS" and "GS × TS" showed significant negative SCA values regarding sex ratio. Their SCA values were -2.53, -3.01, -1.30, -4.22, -5.21, -4.12, -1.12 and -0.94, respectively, indicating that these crosses are the best combinations for the low ratio (Table 4). For the total yield as fruit weight, six F₁ hybrids viz, "HE × ZE", "HE × QU", "ZE × QU", "ZE × GS", "ZE × TC", "QU × GS" and "GS × TC" reflected significant positive SCA values (3.47, 5.21, 3.54, 4.21, 2.11, 2.14 and 2.35, respectively). These results suggest that these hybrids are the best combinations for high total yield (Table 4).

Concerning total soluble solids (TSS %), seven F₁ hybrids, viz, "HE × ZE", "HE × QU", "HE × GS", "ZE × QU", "ZE × GS", "ZE × TC", and "GS × TC" reflected significant positive SCA values (2.51, 3.32, 4.25, 5.21, 6.20, 3.02 and 3.25, respectively). These results indicating that these crosses are the best combinations concerning high TSS content (Table 4).

As a whole, examination of data concerning GCA effects for the studied parental lines in this investigation, showed that certain parents gave high effects for certain characters, but not for all of them. It could be stated that the parents Helpest (HE) and Zentei (ZE) showed high significant effects for all studied traits except the average fruit weight, which showed significant negative value for this trait. These results, generally, postulated that each of the studies parental cultivars can be considered as good combiner for breeding to several traits. In this respect, the parental lines Helpest (HE) and Zentei (ZE) are best of all, since its showed significant GCA values for most studied traits.

Table (4): Estimates of specific combining ability (SCA) effects for some characters in melon.

Parents	Characters	SCA effect				
		HE	ZE	QU	GS	TC
Helpest (HE)	1. Days to fruit maturity		-2.98**	-3.51**	-0.81	-0.99*
	2. Average fruit weight (kg.)		0.31	0.92*	0.68	0.91*
	3. Nodes to first female flower appearance		-0.94*	-0.83*	-1.25*	0.51
	4. Sex ratio		-2.53**	-3.01**	-1.30*	-0.25
	5. Total yield as fruit weight (kg.)		3.47**	5.21**	0.23	-0.11
	6. Total soluble solids (TSS %)		2.51**	3.32**	4.25**	0.53
Zentei (ZE)	1. Days to fruit maturity			-3.01**	-1.02*	-0.97*
	2. Average fruit weight (kg.)			0.98**	-0.05	0.52
	3. Nodes to first female flower appearance			-2.78**	-1.55*	-3.00**
	4. Sex ratio			-4.22**	-5.21**	-4.12**
	5. Total yield as fruit weight (kg.)			3.54	4.21**	2.11**
	6. Total soluble solids (TSS %)			5.21**	6.20**	3.04**
Queen (QU)	1. Days to fruit maturity				-0.73	-0.95*
	2. Average fruit weight (kg.)				0.86*	1.21*
	3. Nodes to first female flower appearance				-1.03*	0.75
	4. Sex ratio				-1.12*	-0.35
	5. Total yield as fruit weight (kg.)				2.14**	0.79
	6. Total soluble solids (TSS %)				0.36	-0.35
Golden Star (GS)	1. Days to fruit maturity					-0.63
	2. Average fruit weight (kg.)					-0.52
	3. Nodes to first female flower appearance					-0.33
	4. Sex ratio					-0.94*
	5. Total yield as fruit weight (kg.)					2.35**
	6. Total soluble solids (TSS %)					3.25**

* Significant at 0.05 level of probability according to the (T) test.

** Significant at 0.01 level of probability according to the (T) test

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A critical examination of data obtained on SCA effects for F_1 hybrids also showed that certain crosses had high SCA effect values for certain traits, but not for all. The best combinations for each studied trait were:

- 1-Helpest \times Zentei (5 from 6 traits): early maturity, few node of first female flower appearance, low sex ratio, high total yield as fruit weight and high total soluble solids (TSS).
- 2-Helpest \times Queen (for all studied traits).
- 3-Helpest \times Golden Star (3 from 6 traits): few of node of first female flower appearance, low sex ratio and high TSS content.
- 4-Helpest \times Tetenyi cseresheju (2 from 6 traits): early maturity and high fruit weight.
- 5-Zentei \times Queen (for all studied traits).
- 6-Zentei \times Golden Star (5 from 6 traits): early maturity, few node of first female flower appearance, low sex ratio, high total yield and high TSS content.
- 7-Zentei \times Tetenyi cseresheju (5 from 6 traits): all studied characters except average fruit weight.
- 8-Queen \times Golden Star (4 from 6 traits): large fruit weight, few number node of first female flower appearance, low sex ratio and high total yield.
- 9-Queen \times Tetenyi cseresheju (2 from 6 traits): early maturity and large fruit weight.
- 10- Golden Star \times Tetenyi cseresheju (3 from 6 traits): low sex ratio, high total yield and high TSS content

Accordingly, these superior and prospective melon materials can be used in melon improvement through breeding programme.

II. Correlation between the studied traits:

The correlation between the different traits in melon is an important aspect which should be utilized for better planning of selection program. This relationship is expressed by the correlation coefficient. A positive or negative direction correlation between the characters may be due to either a pleiotropic effect of a gene on different parts of the plant or to linkage.

Correlation coefficient between various pairs of traits including days to fruit maturity, average fruit weight, nodes to first female flower appearance, total yield and TSS % were studied in 15 entries viz, 10 F_1 hybrids and five parental lines, (Table 5).

Significant positive correlations were found between the following pairs of traits: days to fruit maturity and nodes to first female flower appearance ($r=0.893$) average fruit weight each of nodes the first female flower appearance ($r=0.921$), sex ratio and total yield as fruit weight ($r = 0.825$). Nodes to first female flower appearance and TSS % ($r = 0.640$).

Significant negative correlations were found between the following pairs of traits: days to fruit maturity each of average fruit weight ($r = -0.742$), sex ratio ($r = -0.662$) and total yield as fruit weight ($r = 0.636$). Node of first female

flower appearance and total yield as fruit weight ($r = -0.702$ and sex ratio and total yield as fruit weight ($r = -0.672$). Meanwhile, no other significant were found between pairs of other traits.

Generally, it could be concluded that selection for any one character (for positive correlation), may result in progress for other positively correlated traits. Moreover, these characters could be considered as one selection criterion in melon breeding. These findings are in agreement with those of Abd El-Moneam (1976), El-Doweny (1978), Kitroonouang *et al.* (1992), El-Mighawry (1998), Glala *et al.* (2002) and Jose *et al.* (2005).

Table (5): Correlation coefficient between pairs of the characters studied in 15 melon genotypes (5 parents and 10 F₁).

Characters	Days to fruit maturity	Average fruit weight (kg.)	Nodes to first female flower appearance	Sex ratio	Total yield as fruit weight kg./plant	Total soluble solids (TSS %)
Days to fruit maturity	-0.742*	0.893**	-0.662*	-0.636*	0.397
Average fruit weight (kg.)		0.921**	0.825**	0.833*	0.401
Nodes to first female flower appearance			-0.651*	-0.702*	0.640*
Sex ratio				-0.672*	0.302
Total yield as fruit weight (kg.)					0.233
TSS %					

* Significant at 0.05 level.

** Significant at 0.01 level.

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دراسات علي القدرة على الانتلاف والارتباط في الشمام

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الملخص العربي

أجريت هذه الدراسة في الموسمين الصيفيين المتتاليين ٢٠٠٦ و ٢٠٠٧ بمزرعة محطة بحوث البساتين بالقناطر الخيرية بهدف الحصول على المزيد من الايضاحات والمعلومات في وراثته بعض الصفات في الشمام للمساعدة في اعداد برامج التربية وتحسين الشمام . واستخدم في هذه الدراسة خمسة أصناف هي (هيلبست - زيني تي - كوين - جولدن ستار - وتيتاني كسيرجو) - حيث أجرى التهجين بينهم في العام الأول للحصول على بذور الجيل الأول اللازمة للدراسة - وفي العام الثاني زرعت الأباء الخمس والعشرة هجن الناتجة في تجربة مصممة بطريقة القطاعات الكاملة العشوائية ، في ثلاث مكررات - وأخذت القياسات اللازمة على : عدد الأيام من الزراعة وحتى نضج الثمرة ، ومتوسط وزن الثمرة ، وأول عقدة تحمل زهرة مؤنثة ، النسبة الجنسية ، المحصول الكلي ، والمواد الصلبة الذائبة الكلية .

وبعد تحليل البيانات المتحصل عليها كانت أهم النتائج :

- [١] كان التباين لكل من القدرة العامة والخاصة على الانتلاف معنوياً لكل الصفات المدروسة مما يؤكد على أهمية كل من الفعل المضيف والغير مضيف للجينات في وراثته هذه الصفات
- [٢] أظهرت النسبة المحسوبة بين متوسط مربعات الانحرافات للقدرتين العامة والخاصة على الانتلاف أن الفعل المضيف كان أكثر أهمية في وراثته جميع الصفات المدروسة ما عدا صفتي (أول عقدة تظهر عليها أول زهرة مؤنثة - والنسبة الجنسية) . مما يؤكد أهم الجينات الغير مضيفة (السيادة) عن الجينات المضيفة في هاتين الصفتين .
- [٣] اختلفت الآباء في تأثيرات القدرة العامة على الانتلاف وعموماً فإن الصنفين (هيلبست - زيني تي) كانا أفضل الأصناف حيث اعطى تأثيرات عامة على الانتلاف لجميع الصفات المدروسة .

[٤] أظهرت حسابات تأثيرات القدرة الخاصة على الانتلاف للهجين المختلفة أن أفضل الاتحادات للصفات المدروسة كان في الهجن الآتية : (هلبست × كوين) والهجين (زينيتى × كوين) حيث أعطيا تأثيرات معنوية في جميع الصفات المدروسة ويلاحظ أن هذان الهجينان يدخل في تكوينهما أحد الآباء الذي أعطى قيم معنوية في القدرة العامة على الانتلاف – ولهذا يمكن الاستفادة بهما في برامج التربية لتحسين الشامام .

[٥] وجدت علاقات معنوية موجبة بين كل من الأزواج التالية من الصفات:

– التبكير في الحصاد وأول عقدة تخرج عليها أول زهرة مؤنثة.

– متوسط وزن الثمرة وكلا من : أول عقدة تخرج عليها أول زهرة مؤنثة ، والنسبة الجنسية ، والمحصول الكلى .

– أول عقدة تخرج عليها أول زهرة مؤنثة ومحتوى الثمار من المواد الصلبة الذائبة الكلية

[٦] أظهرت النتائج عن وجود علاقات سالبة بين كل من الأزواج التالية من الصفات :

– عدد الأيام حتى نضج الثمرة وكلا من : متوسط وزن الثمرة ، النسبة الجنسية ، المحصول الكلى.

– أول عقدة تظهر عليها أول زهرة مؤنثة وكلا من: النسبة الجنسية، والمحصول الكلى للثمار.

ومن هذه العلاقات (الموجبة أو السالبة) يمكن الاستفادة في برامج التربية حيث يمكن الانتخاب لأكثر من صفة في وقت واحد حيث يوجد الارتباط.