J. Plant Production, Mansoura Univ., Vol. 5 (5): 869-883 , 2014

COMBINING ABILITY ANALYSIS FOR YIELD AND ITS ATTRIBUTING TRAITS IN TOMATO (*Lycopersicon esculentum* Mill.)

Ramadan, W. A.*;S. T. El-Afifi and P. A. Abdelmalek ***

*** Horticulture Res. Instit, Agric. Res. Center**

**** Fac. Of Agric. Mansoura university**

ABSTRACT

The inheritance studies of some quantitative and qualitative characteristics of tomato were carried out using a half diallel crosses mating design to obtain 15 crosses among 6 genotypes.

General (GCA) and Specific (SCA) combining abilities were significant or highly significant for all studied traits. The large magnitude of (GCA) for the vegetative, and total soluble solids (TSS %) traits suggested the importance of additive genetic effects, while the large magnitude of (GCA) and (SCA) for fruit set percentage (FS %), earliness, total yield, average fruit weight (AFW), fruit firmness (FF), number of locules per-fruit (NL/F) and fruit thickness (FT) suggested the importance of additive and non-additive genetic effects.

B_{5357} cultivar (P5) was a good combiner for plant height (PH), fruit set percentage (FS %), early fruit number (EFN), total fruit number (TFN), total fruit weight (TWF) and total soluble solids (TSS %). Edkawy cultivar (P2) also, was a good combiner for number of branches per plant (NB/P) and number of locules per-fruit (NLF) while Fline cultivar (P6) was a good combiner for average fruit weight (AFW), fruit firmness (FF), and fruit thickness (FT).

INTRODUCTION

Tomato is one of the most consumed and widely grown vegetable crops in the world including Egypt.

Many searchers as Abd El-Rahman (1993), Zanata (1994) and Mehdi, et al. (2008), studied combining ability on tomato and they referred that the general combining ability (GCA) was significant and higher in magnitude than the corresponding value of specific combining ability (SCA) and consequently the ratio of additive variance (σ^2A) to dominance variance (σ^2D) was greater than unity suggesting the predominance of additive gene action for plant height and number of branches per plant. On the other hand, Sekhar, et al. (2007), reported, that on tomato, for plant height character, the σ^2 GCA/ σ^2 SCA ratio was less than unity indicating the predominance of non-additive effect. In case of number of branches per plant σ^2 GCA/ σ^2 SCA was greater than unity reveals that predominance of additive effect and more GCA variance than SCA variance, These results were in close proximity with the results of, Dharmatti *et al*.(1996), Sharma, *et al.* (1999), Patil (2003), and Amin *et al*. (2001) in case of single crosses. While, Konsouh and zakher (2011), reported that both general and specific combining abilities were highly significant for plant height and number of branches.

El-Adl *et. al*. (1984) estimated the type of gene effects contributing to the genetic variation of flowering traits. They reported that the magnitudes of additive genetic variation appeared to be larger than those of dominance genetic variance with respect to most of flowering traits. While, Shrife and Hussien (1992), Zanata (1994) reported that, additive and non-additive genetic variances were significant for percentage of fruit set in tomato. And Shalaby *et.al*. (1983), Khalil *et al*. (1988), Metwally *et al*. (1990) and Zanata (1994) and Konsouh and Zakher (2011) for early yield. While, Wahb-Allah (1995) and Salib (1999 indicated the presence of various degrees of dominance and over dominance controlling the inheritance of early yield.

Metwally *et al.* (1990) reported on tomato that, general and specific combining ability for total yield were found highly significant. The additive gene effects appeared more important than non-additive gene effects. Meanwhile, Sekhar *et.al,* (2007) found that, the σ^2 GCA/ σ^2 SCA ratio was 0.027 hence it revealed that for this trait non-additive effects and higher SCA variance was important. These results were in close proximity with the findings of Dharmatti *et.al.* (1996) and Patil (2003) and Muhammad, et al. (2009).while, Singh, *et al*. (2011) found that GCA and SCA variance were highly significant for total yield and its component. These results were in close proximity with the results of Mehdi, *et al*. (2008) and Konsouh and Zakher. (2011).

Omara *et al.* (1988) found in tomato that, additive genetic variance formed the major part of total genetic variation for average fruit weight, but the non-additive variance was also significant. Dominance was partial, directional dominance was operating for smaller fruit weight.

Metwally *et al.* (1990) found on tomato grown under high temperature that general combining ability was highly significant for this trait. However specific combining ability was insignificant. The additive gene effects appeared more important than non-additive gene effects. These results were in accordance with study of workers Dobhol *et.al.* (1999) and Garg et al. (2008). Sekhar *et.al*, (2007), found on tomato that, for average fruit weight, non-additive effects were predominant with higher SCA variance. However, Konsouh and Zakher (2011) reported, general and specific combining ability were highly significant for average fruit weight.

Kanno and Kamimurra (1981) and Salib (1999) reported partial dominance for the soft fruit. While Khalil *et al*. (1988) found, on tomato some crosses exhibited no dominance for the fruit firmness, other ones exhibited partial dominance to the low or high parent. In one cross the dominance for softness was observed. Also, Garg *et al*. (2008) found on tomato that, non-additive genetic variance predominated in controlling firmness index under both normal and late planting conditions. While, Konsouh and Zakher (2011) studied combining ability of eleven female parents and three male parents on tomato and reported that, general and specific combining ability were highly significant for firmness.

Kanno and Kamimura (1981) found, on tomato, that some crosses showed complete dominance predominated in controlling the high T.S.S content, while the other crosses showed complete dominance predominated in controlling the low content of T.S.S%. Meanwhile, Metwally *et al.* (1990) found, that both general and specific combining abilities for T.S.S% were highly significant. The additive gene effects appeared more important than non-additive one. Although, Amin *et al.* (2001) and Garg *et al*. (2008) found, on tomato, that the large magnitudes of non-additive genetic variance including dominance for T.S.S While, Konsouh and Zakher (2011) reported that, both general and specific combining abilities were highly significant for T.S.S.

Dod and Kale (1992) found on tomato that the higher magnitude of GCA compared with SCA for number of locules and fruit wall thickness indicated a predominant role of additive gene action. On the other hand, Patil (2003) and Sekhar *et al* (2007) found in tomato for pericarp thickness that, σ^2 GCA/ σ^2 SCA ratio was 0.047 indicating the importance of non-additive effects and SCA variance. These results were in accordance with study of earlier workers Dharmatti *at al*. (1996).and Garg *et.al.* (2008). The objectives of this investigation were to estimate the type of gene action and factors controlling the inheritance of tomato traits.

MATERIALS AND METHODS

Six tomato cultivars used in this investigation were presented in Table (1):

No.	Genotype	F.S	G.H	Maturity	Origin	Resistance to
1	Castle Rock	L	D	M	USA	--
2	Edkawy	L	D	M	Egypt	Salinity
3	Super Marmand	L	D	M	France	--
4	Floraded	L	SD	Late	USA	--
5	B_{5357}	S	SD	Early	USA	Bacterial Speck and tolerant early blight
6	Fline	M	D	Early	France	Late blight

All cultivars are belonging to the species *Lycopersicon esculentum Mill*. Plant from each variety was salved for three generations to end up with an inbred line from each variety. This work was carried out during 3 successive years. In 2009, all possible combination crosses were executed in a half diallel mating design to produce 15 F_1 seeds.

Experiment design:

The experimental design used was a randomized complete block design with three replications. Each replicate or block contained 21 experimental units or plots (6 parents, 15 F_1). The 21 genotypes were sown in nursery in seedling trays on April 5th of 2010 and 2011and the seedlings were transplanted on May 5th. Each plot was two ridges, each 6m long and 1.25m wide and plants spaced 40 cm within ridges per block. All cultural practices were done as in the commercial production of tomato in Elwazer village , Gamsa Road.

Data recorded:

1) Vegetative traits:
- Plant height after 60 days from transplanting (PH).
- Number of branches per plant after 60 days from transplanting (NB/P).

2) Flowering traits:
- Fruit set percentage (FS %)

3) Earliness traits:
- Early fruit number (EFN)per plant
- Early fruit weight (EFW)per plant

4) Total yield traits :
- Total fruit number (TFN) per plant
- Total fruit weight (TFW) per plant

5) Fruit quality traits:
- Average fruit weight (AFW)
- Fruit firmness (FF)
- Total soluble solids (TSS %)
- Number of locules per-fruit (NLF)
- Fruit thickness (F.T)

Statistical procedures:

The diallel crosses:

The variation among parents and F_1 crosses was partitioned separate and combined data into general and specific combining ability as illustrated by Griffing (1956), method (2) model (1).

RESULTS AND DISCUSSION

Vegetative traits:

Analysis of variance for both plant height (Ph) and number of branches per plant (NB/P) in the 6x6 half diallel is shown in Table (2) at two years. The results showed that the (GCA) was highly significant for both traits at two years except plant height at the second year was significant. Also, (SCA) was highly significant for both traits at the two years except plant height at the second one which was insignificant. Therefore, the additive gene effects were more important than non-additive gene effects. In this concern Mehdi *et.al* (2008) found the same results.

The combined analysis of variance of half diallel crosses were presented in Table (3) for plant height (Ph) and number of branches per plant (NB/P). The results showed that the GCA and SCA were highly significant for all traits. The magnitudes of the GCA and SCA by year's interaction were not significant for both traits. The large magnitude of GCA for both traits suggesting the importance of additive gene action. These results were agreed with the results of Zanata (1994).

The GCA Effects estimates for plant height (PH) and number of branches per plant (NB/P) were presented in Table (4) at two years. The results showed that B5357cultivar had the greatest GCA effects (29.42 ± 2.70) and (19.41 ± 2.73) for plant height (PH) at the first and second years, respectively. While the other parents were poor combiner at two years. Also the results showed that Edkawy cultivar had the greatest GCA effects (1.28 ± 0.29) and (1.595 ± 0.38) for number of branches per plant (NB/P) at the first and second years, respectively. While the other parents were poor combiner at two years.

The GCA combined data were presented in Table (5) showed the same results of both years.

The SCA effects estimates for plant height (PH) and number of branches per plant (NB/P) were presented in Table (6) at two years. The results showed that cross (1 X 5) had the greatest value and highly significant (SCA) effects for both traits at the first year, While both crosses (5 X 6) and (1 X 5) the greatest values and highly significant (SCA) effects for plant height (PH) and number of branches per plant (NB/P),respectively at the second years.

The combined data were presented in Table (7) showed that the cross (5 X 6) had the greatest value and highly significant SCA effects but, cross (3 X 4) was lowest significant value for plant height. While, the cross (1 X 5) had the greatest value and highly significant SCA effects but, cross (2 X 5) was significantly lowest value for number of branches per plant.

Flowering traits:

The analyses of variance of the half diallel crosses were presented in Table (2) for fruit sets (FS %) at two years. The results showed that both GCA and SCA were highly significant for this trait at two years. The combined analysis of variance of half diallel crosses Table (3) showed that the GCA and SCA were highly significant. Also, the magnitudes of the (GCA x Y) and (SCA x Y) interactions were highly significant revealing the importance of both additive and non-additive gene action in the inheritance of fruit sets. These results agree with Shrife and Hussien (1992) and Zanata (1994)

The GCA effects estimates for fruit sets (FS %) were presented in Table (4) at two years. The results showed that Super Marmand and B_{5357} cultivars were highly significant and positive GCA effects but other parents were poor combiner at two years. The combined data in Table (5) showed that the parent B_{5357} had the greatest GCA effects (2.63 ± 0.431), while the other parents were poor combiner.

The SCA effects estimates for fruit sets (FS %) trait was presented in Table (6) at two years. The results showed that crosses (2X3, 5X6, 1X4, and3X5) had the greatest values and highly significant SCA effects for this trait at the first year, while the crosses (2X6, 5X6, and 3X4) were the greatest value and highly significant SCA effects at the second years. The combined data for fruit sets (FS %) were presented in Table (7) showed that crosses (2X6), (5x6), (3X4), and (3X5) were highly significant and positive SCA effects.

Earliness traits:

The analysis of variance of diallel crosses was presented in Table (2) for two earliness traits, i.e. early fruit number (EFN) and early fruit weight (EFW) at two years. The results showed that the GCA was highly significant for all traits at two years. Also, SCA was highly significant for all traits at two years except early fruit weight at the second year. Therefore, the additive gene action was more important than non-additive one (Metwally et.al. 1999 and Zanata 1994).

The combined analysis of variance in the 6x6 half diallel was presented in Table (3) for early fruit number (EFN) and early fruit weight (EFW) at two years. Results showed that both GCA and SCA were highly significant for all earliness traits. Also, the interaction of half diallel crosses by years showed that their mean square were highly significant for early fruit number (EFN) and early fruit weight (EFW). The magnitudes of both GCA x y and SCA x y interaction were highly significant for early fruit number (EFN) trait and significant for early fruit weight (EFW) trait. The results indicate the importance of additive and non-additive genetic effects. These results agreements with the results of, Khalil et.al. (1988), Konsouh and Zakher. (2011).

The (GCA) effects estimates for early fruit number (EFN) and early fruit weight (EFW) traits were presented in table (4) at two years. The results showed that (P4) cultivar had the greatest GCA effects (18.82 ± 2.71) and (1.61 ± 0.39) for (EFN) and (EFW) traits followed by (P5) with value (12.68 ± 2.71) for (EFN) at the first year. In the second year (P5 and P4) cultivars were the greatest GCA effects with value (11.27 ± 1.32) and (0.61 ± 0.25) for (EFN) and (EFW), respectively. While the other parents were poor combiner for those traits at two years.

The combined data were presented in table (5) showed that the parent (P5) was highly significant and greatest value (11.98 ± 1.51) for early fruit number (EFN) so, this parent considers the greatest combiner for early fruit number (EFN) but all parents were poorest combiners. While, the parent (P4) was highly significant and greatest value (1.11 ± 0.23) for early fruit weight (EFW). so, this parent considers the greatest combiner for early fruit weight (EFW).

The SCA effects estimates for early fruit number (EFN) and early fruit weight (EFW) traits were presented in Table (6) at two years. The results showed that (8 out 15) crosses showed positive values of SCA but 5 crosses only were positive significant or highly significant SCA effects for (EFN). While, (8 out 15) crosses showed positive values of SCA but 3 crosses only were significant for (EFW). Cross (4X5) had the greatest SCA effects for both EFN and EFW with value (111.28 ± 6.15) and (4.61 ± 0.88), respectively at first year.

Also the result showed that (11 out 15) and (10 out 15) crosses showed positive values SCA effects for (EFN) and (EFW) traits, respectively. But only 3 crosses were significant for (EFN) trait and non significant crosses for (EFW) at the second year.

The combined data were presented in Table (7) showed that crosses (1X6, 2X6 and 4X5) were highly significant and positive SCA effects for two traits. Also the cross (2X4) was highly significant and positive SCA effects for early fruit number (EFN).

234

Total yield traits:

The analysis of variance of diallel crosses were presented in Table (2) total fruit number (TFN) and total fruit weight (TFW) traits at two years. The results showed that the GCA was highly significant for both traits at two years. Also the SCA was highly significant for total fruit weight (TFW) trait at two years and significant for total fruit number (TFN) at only second years. Therefore, the additive gene action was more important than non-additive one. These findings are consistent with both Metwally et,al (1999), and Konsouh and Zakher. (2011).

The combined analysis of variance of half diallel crosses results was presented in Table (3) for total fruit number (TFN) and total fruit weight (TFW) traits at two years. The results showed that both GCA and SCA were highly significant for total yield traits in this concern Mehdi *et.al*. (2008) and Singh, *et. al.* (2011). The interaction of half diallel crosses by years were highly significant for total fruit number (TFN) and total fruit weight (TFW). The magnitudes of the GCA by year's interaction were highly significant for all traits. However the SCA by year's interaction were not significant for any traits suggesting the majority of additive genetic variance although the significance of the non-additive variance (Metwally *et.,al.* (1999)**.**

The GCA effects estimates for total fruit number (TFN) and total fruit weight (TFW) traits were presented in Table (4) at two years. The results showed that (P_5) cultivar had the greatest GCA effects $(316.98 \pm 27.59$ and $9.76 \pm 1.24)$ for both traits at the first year and $(91.30 \pm 12.85$ and $2.79 \pm 0.81)$ at the second years, respectively .While the other parents were poor for these traits at two years.

The combined data were presented in Table (5) showed that the parent (P_5) were highly significant and positive GCA effects (204.14 ± 15.21) and (6.28 ± 0.74) for total fruit number (TFN) and total fruits weight (TFW) traits, respectively. So, this parent considers the greatest combiner for total yield traits but all parents ware poor combiner.

Table1 (5): General combining ability effects (gi) for arrays in combined data over both years,.

FT	NLF	TSS%	FF	AFW	TFW (kg)	TFN	EFW (kg)	EFN	FS%	NB/P	PH (cm)	Parents
0.16	0.34*	-0.21**	-0.15**	3.48**	0.82	-19.61	0.10	-7.13**	-0.97*	0.63*	-7.95**	P_1
-0.12	0.53**	-0.03	-0.12**	1.29	-5.52	-84.88**	-0.92**	-9.48**	-1.95**	1.44*	-3.54	P_2
0.00	0.44**	0.12**	0.10*	2.87*	-0.52	-34.37*	0.37	-3.12*	1.94**	-0.19	-7.83**	P_3
-0.09	0.23	-0.14**	0.01	-0.24	-0.08	-5.51	1.11**	9.79**	-0.50	-0.81**	4.36*	P_4
-0.38**	-0.63**	0.28**	0.02	-14.65**	6.28**	204.14**	-1.31**	11.98**	2.63**	-1.22**	24.41**	P_5
0.43**	-0.91**	-0.02	0.15**	7.25**	-0.98	-59.77**	0.66**	-2.03	-1.16**	0.16	-9.45**	P_6
0.1115	0.1552	0.0352	0.0454	1.2231	0.7403	15.2162	0.2319	1.5099	0.4318	0.2402	1.9182	SE

***, ** Significant at 0.05 and 0.01 levels of probability, respectively**

The data in Tables (6) showed that the crosses 1X5, 3X5 and 4X5 had the greatest values and significant SCA effects for total fruits number (TFN) trait at the first year and only the cross (2X4) at the second one. While, the crosses 2X4 and 3X5 were the greatest value and highly significant SCA effects for total fruits weight (TFW) at two years. Also, the crosses (1X5 and 3X6) at the first year and cross (2X3) at the second one were the greatest values and highly significant SCA effects for the same trait.

The combined data were presented in Table (7) showed that three crosses (2X4, 3X6 and 4X5) were positive significant or highly significant SCA effects for total fruits number (TFN) trait , while Six crosses showed positive values significant or highly significant SCA for total fruit weight (TFW) trait.

Fruit quality traits:

The analysis of variance of diallel crosses at two years and combined analysis of variance of GCA and SCA for five fruit quality traits i.e., average fruit weight (AFW), fruit firmness (FF), total soluble solid (TSS %), number of locules (NLF) and flesh thickness (FT) were presented in Tables (2,3). The results showed that the GCA was highly significant at two years while, the SCA was only highly significant at the second year for average of fruit weight (AFW). While the combined analysis of variance of GCA and SCA were highly significant and significant, respectively for the same trait, the interaction of half diallel crosses by years showed that. The magnitudes of the GCA by year's interaction were highly significant, indicating the importance of additive one than non-additive gene action these results agreements with the results of Metwally *et.al,* (1990)

The GCA was highly significant fruit firmness (FF) in only 2nd year and SCA was significant at the first year for fruit firmness. While the combined analysis of variance of GCA and SCA were highly significant for the same trait. The interaction of half diallel crosses by years showed that, the magnitudes of the GCA and SCA by year's interaction were not significant. These results indicate the importance of additive and non-additive genetic effects. These results agreements with the results were obtained by Konsouh and Zakher (2011)

With respect to TSS trait; the GCA was highly significant at two years, but the SCA was not significant at both years. The combined analysis of variance of GCA was highly significant, while SCA was only significant. The magnitudes of the GCA by years interaction was significant, but the SCA by years interaction was not significant indicating, the additive gene action appeared more important than non-additive gene action, Metwally *et.al.* (1990)

The results of number of locules (NLF) and flesh thickness (FT) traits at two years showed that the GCA and SCA were highly significant at first year and highly significant or significant at second year. The combined analysis of variance of GCA and SCA were highly significant for these traits but the magnitudes of the GCA and SCA by year's interaction were not significant indicating the importance of both additive gene action and non-additive gene action. These findings are contrast with, Dod and Kale (1992) they, indicated a predominant role for additive gene action, and Sekhar *et.al* (2007) they indicating the importance of non-additive effects in inheritance of number of locules (NLF) and flesh thickness (FT) traits**.**

6

The GCA Effects estimates for average fruit weight (AFW), fruit firmness (FF), total soluble solids (TSS %), number of locules (NLF) and flesh thickness (FT) traits were presented in Table (4) at two years. The results showed that (P6) had the greatest GCA effects(10.03 ± 1.59),(0.11 ± 0.05) and (0.55 ± 0.16) for average fruit weight (AFW), fruit firmness (FF) and flesh thickness (FT) at the first year, respectively and(4.47 ± 1.85),(0.18 ± 0.07) and (0.32 ± 0.16) at the second one, respectively so it's a good combiner for these traits. Also, (P5) had the greatest GCA effects with values(0.24 ± 0.05) and (0.33 ± 0.05) for total soluble solid (TSS %) at first and second years, respectively. so it's a good combiner for this trait. While the (P_2) in the first year and (P_3) in the second one had the greatest GCA effects for number of locules (NLF) with values (0.59 ± 0.16) and (0.87 ± 0.26), respectively. But the other parents were poor for all traits at two years.

The combined data presented in Table (5) showed that, the parent (P6) were highly significant and positive GCA effects with values $(7.25 \pm 1.22), (0.15 \pm 0.05)$ and(0.43 ± 0.11) for average of fruit weight (AFW), fruit firmness (FF) and flesh thickness (FT) traits, respectively so it's a good combiner for these traits. Results also showed that the parent (P_2) was highly significant and positive GCA effects with value (0.53 ± 0.15) for number of locules (NLF), also (P5) with (0.28 ± 0.04) for total soluble solids (TSS %).so, these parents consider the greatest combiner for these traits but other parents were the poorest combiners.

The data were presented in Table (6) at two years showed that cross (2X5) had the greatest value and insignificant SCA effects were observed for average of fruit weight (AFW) at the first year but the crosses (1X4, 3X5 and 4X6) had the greatest value and highly significant SCA effects for the same trait in the second year . The cross (4X5) had the greatest value and highly significant SCA effects at two years and the cross 2X3 at the first year for fruit firmness (FF). The cross (4X6) had the greatest value and highly significant SCA effects for total soluble solids (TSS %) at two years also, the crosses (1X4 and 4X5) for number of locules (NLF) and at the first and second year, respectively. The result showed that crosses (4X6 and 3X5) were highly significant and the crosses (1X6 and 2X4) were only significant at the first year ,while the crosses (1X6, 2X4, 5X6) had the greatest value and significant SCA effects at the second year for flesh thickness (FT) trait.

The combined data presented in Table (7) showed that both (4X6 and 1X4) were highly significant and positive SCA effects for average fruit weight (AFW).

7

Also the crosses (4X5, 2X3) and (1X6) were positive highly significant and significant SCA effects, respectively for fruit firmness (FF) and cross (4X6) for total soluble solid (TSS %). While the cross (4X5) was significant for number of locules (NLF) but theses crosses (1X6, 2X4, 3X5 and 4X6) were highly significant and positive SCA effects for flesh thickness (FT).

It could be concluded that the present study indicated that importance of additive genetic effects for vegetative growth , and total soluble solids (TSS %) traits, therefore the selection is the best method to improve these traits, while the importance of additive and non-additive genetic effects for fruit set percentage (FS%), earliness ,total yield ,average fruit weight (AFW), fruit firmness (FF), number of locules per-fruit (NL/F) and fruit thickness (FT) reveling the recurrent selection is the best method to improve these traits.

REFERANCES

Abd El-Rahman, M. M. (1993). Combining ability and nature of gene action in some hybrids of tomato (Lycopersicon esculentum Mill). M.Sc. Thesis, Mansoura University, Egypt.

Amin, E. S. A.; M. M. Abd El-Maksoud and A. M. Abd El-Rahim (2001). Genetical studies on F_1 hybrids, F_2 generations and genetic parameters associated with it in tomato. (Lycopersicon esculentum Mill). J. Agric. Sci. Mansoura Univ., 26(6): 3667-3675.

Borém, A. and G.V Miranda (2005). Melhoramento de plantas. 5.ed. Viçosa: UFV,.525p.

Dharmatti, P. R.; J. B. Madalageri; R. V. Patil and V. D. Casti (1996). Heterosis studies in tomato. Karnataka J. Agric. Sci., 9(4); 642-648.

Dobhol, T. L.arid and M. I. Qadri (1999). Combining ability analysis of fruit firmness and related traits in tomato. J. Hill. Res. (Hisal) 12(1): 31-33 [C. F. Plant Breed. Abstr., 7(1):809].

Dod, V.N. and P.B. Kale (1992). Heterosis for certain quality traits in tomato (Lycopersicon esculentum Mill). Crop Res. (Hisal) 5(2): 302-308 [C. F. Plant Breed. Abstr., 64: 10673].

El-Adl, A. M.; Z. A Kosba; T. M. El-Gazar and M. M. Abed Alrahman (1984). Combining ability and heritability for yield and its components in tomato (Lycopersicon esculentum Mill.). J. Agric. Sci. Mansoura Uni., 9(2): 283-287.

Garg N. ; Devinder S. and Cheema Ajmer S. (2008). Genetics of yield, quality and shelf life characteristicsin tomato under normal and late planting conditions.J. Euphyticaplant breeding, 159:275–288

Griffing, J. G. (1956). Concept of general and specific combining ability in relation to diallel crossing system. Australian J. Biol. Sci., 9:463-493.

Hannan, M. ,B. Ahmed and U.K. Roy (2008). Heterosis, combining ability and genetics for Brix%, Days to First Fruit Ripening and Yield in Tomato (*Lycopersicon esculentum* Mill.). Middle-East Journal of Scientific Research 2 (3-4): 128-131, 2007

Hassan K. , I. Ahmad and Nisreen Raslan (2008). A study of general and specific combining ability and heterosis for earliness characteristic at six tomato varieties (*Lycopersicon esculentum* L.) and their hybrids. Tishreen univ. J. for research and scientific studies

Hatem, K. K. (1994). Heterosis and nature of gene action in tomato. M.Sc. Thesis. Minufiya univesity biological sci. vol. (30) no. (4).

Kanno, T. and S. Kamimura (1981). Fruit structure, firmness and quality and relationship between these factors in varieties and F_1 hybrids of tomatoes. Versailles, France: INRA (1981) 99-119 [C. F. Plant Breed. abs. 53:1664].

Konsouh, A. M. and A. G. Zakher (2011). Gene action and combining ability in tomato (*Lycopersicon esculentum* Mill.) by line x tester analysis. J. plant pro. Mansoura univ.., vol. 2(2):213-227

Khalil, R. M.; A. A. Midan and A. K. Hatem (1988). Breeding studies of some characters in tomato (*L. esculentum* Mill.) acta Horticulture, 220:77-83.

Mehdi S., S. D. Warade and T. Pravu (2008). Combining Ability Estimates for Yield and its Contributing Traits in Tomato (*Lycopersicon esculentum*).International journal of agriculture & biology., online: 1814–9596 /۳۱۸–۰۷ RAS/2008/10–2–238–240 http://www.fspublishers.org

Metwally, E. I.; G. El-fadaly and A. Y. Mazrouh (1990). Inheritance of yield and fruit quality under heat stress conditions in Egypt. J. Agric. Res. Tanta univ. 16: 517-527.

Muhammad Y. S., Muhammad A., M. Ahsanul H., Tariq R., Atif K. and Asif A (2009). Geneticanalysis to identify suitable parents for hybrid seed production in to tomato (Lycopersicon esculentum Mill.).Pak. J. Bot., 41(3): 1107-1116, 2009.

Omara, M. K.; S. E. A. younis, T. H. I. Sherif; M. Y Hussein and H. M. El-Aref (1988). A genetic analysis of yield and yield component in the tomato (Lycopersicon esculentum Mill). Assuit J. Agric. Sci. 19:227-238.

Patil, V. S.,(2003). Studies on double crosses involving potential tomato hybrids. M. Sc. (Agri.) Thesis, uni. Agric. sci. Dharwad (India).

Ray, N. and M. M. Symal (1999). Genetic architecture of morphological traits in tomato- Orissa J. Hort. 26(3): 7-9 [C.F. Plant Breed. Abs. 70:791].

Salib, F.S. (1999). Genetical studies on some morphological and physiological characters of tomato varieties (Lycopersicon esculentum Mill). Ph. D. Thesis ain Shams Univ. Egypt.

Sekhar, B. G. Prakash, P. M. Salimath, Channayya. P. Hiremath and O. Sridevi (2007). Genetic diversity among F1 hybrids (parents) and evaluation of DCH (double cross hybrids) following diallel analysis in popular privet ate tomato hybrids. Msc. Thesis University of Agricultural Sciences, Dharwad.

Shalaby, G.I.; M.K. Imam; A. Nasar; E.A. Waly and M.F. Mohamed (1983). Studies on combining ability of some tomato cultivars under temperature conditions. Assuit. J.Agric. Sci. 14:35-56.

Sharma, D.K., D.R. Chaudhary and P.P. Sharma.1999. Line x tester analysis for study of combining ability of quantitative traits in tomato. Ind. J. Hort., 56(2): 163-168.

Shrife, T.H.I. and H.A. Hussein(19992). A genetic analysis of growth and yield characters in tomato (*Lycopersicon esculentum* Mill.) under the heat stress of late Summer in upper Egypt. Assuit. J. Agric. Sci. 23(2): 3-28.

Singh, S. K. Singh, R. K. Naresh, K. V. Singh, S. K. Bhatnagar and Ashok Kumar (2011) general combining ability analysis of yield and its contributing traits in tomato (*Lycopersicon esculentum*, Mill) Plant Archives Vol. 11 No. 1, 2011 pp. 201-204.

Wahb-Allah, M.A.E. (1995). Studies on general performances combining ability and heritability of growth and productivity of some tomato cultivars and their hybrid combination M.Sc. Thesis, Alx. Univ., Egypt.

Zanata, O.A. (1994). Heterosis and gene action in varietal crosses of tomato in late summer season. M.Sc. Thesis. Kafr El-Sheikh, Tanta Univ., Egypt.

تحليل القدرة علي التآلف للمحصول و مكوناته في الطماطم

وهبة علي السيد رمضان* و سمير طه العفيفي و بولا النجاشي عبد الملك***

*** بحوث الخضر ذاتية التلقيح- معهد بحوث البساتين – مركز البحوث الزراعية – الجيزة – مصر**

**** قسم الخضر – كلية الزراعة – جامعة المنصورة - مصر**

درست وراثة بعض صفات الجودة والمحصول في ست أصناف من الطماطم هجنت بنظام النصف دائري في اتجاه واحد وأشارت النتائج إلي: -

- كانت القدرة الخاصة و العامة علي الائتلاف عالية المعنوية أو معنوية لكل الصفات المدروسة.
- أشارت عظم قيم القدرة العامة علي الائتلاف لصفات النمو الخضري و المواد الصلبة الكلية للثمار علي أهمية التأثير الإضافي .
- كذلك عظم قيم القدرة العامة و الخاصة علي الائتلاف لصفات نسبة العقد و التبكير و المحصول الكلي و متوسط وزن الثمار و صلابة الثمار وعدد المساكن في الثمرة وسمك اللحم يشير إلي أهمية كل من الفعل السيادي و الإضافي في وراثة تلك الصفات.
- كان الصنف B_{5357} ذي قدرة ائتلافية عامة كبيرة لصفات طول النبات نسبة العقد وعدد الثمار المبكر و المحصول الكلي وزنا و عدد الثمار و المواد الصلبة الكلية للثمار.
- كان الصنف الإدكاوي ذو قدرة ائتلافية عامة عالية لصفات عدد الأفرع علي النبات و عدد المساكن في الثمار بينما كان الصنف فلاين ذي قدرة ائتلافية عامة عالية لصفات متوسط وزن الثمار و صلابة الثمار وسمك اللحم في الثمار.

Table (2): Mean squares of diallel crosses for vegetative (PH – NB/P), flowering (FS %), earliness (EFN - EFW), total yield (TFN - TFW) and fruit quality (AFW – FF – TSS % - FT) traits in F_1 hybrids, at two years.

FT	NLF	TSS%	FF	AFW	TFW (kg)	TFN	EFW (kg)	EFN	FS%	NB/P	PH (cm)	d.f	years	S. O. V
0.82**	3.04**	0.23**	0.07	900.52**	244.80**	201306.52**	13.61**	1262.21**	22.15**	9.30**	2017.10**	5	Y_1	G.C.A
0.60*	3.79**	0.35**	0.17**	228.94**	44.28**	21282.29**	3.20**	341.53**	48.73**	6.73**	829.42*	5	Y_2	
0.912**	0.93**	0.03	0.078*	24.43	76.01**	12553.44	4.91**	1455.59**	9.41**	5.30**	317.89**	15	Y1	S.C.A.
0.64**	1.30*	0.04	0.06	93.32**	25.89**	3824.53*	0.72	47.37**	22.46**	5.78**	119.39	15	Y2	
0.233	0.257	0.024	0.036	24.410	14.779	7306.891	1.4449	70.72	1.79	0.80	69.7407	40	Y_1	Error
0.244	0.668	0.024	0.043	33.031	6.266	1583.977	0.62	16.82	5.37	1.42	71.56	40	Y_2	

Table (3): The combined analysis of variance for general and specific combining abilities for studied traits.

FT	NLF	TSS%	FF	AFW	TFW (kg)	TFN	EFW (kg)	EFN	FS%	NB/P	PH (cm)	d f	S. O. V.
1.21**	6.01**	0.51**	0.22**	925.90**	229.59**	172948.62**	13.99**	1260.84**	54.55**	14.97**	2692.42**	5	G.C.A
1.37**	2.09**	0.06*	0.14**	64.71*	85.40**	11437.95**	3.18**	786.65**	21.20**	9.45**	391.98**	15	S.C.A
0.21	0.82	0.07*	0.019	203.55**	59.48**	49640.19**	2.82*	342.90**	16.33**	1.07	154.10	5	G.C.A X Y
0.18	0.15	0.0071	0.0075	53.04	16.51	4940.02	2.44*	716.32**	10.67**	1.63	45.31	15	S.C.A X Y
0.239	0.463	0.024	0.040	28.721	10.522	4445.434	1.032	43.770	3.580	1.108	70.648	80	Error

***, ** Significant at 0.05 and 0.01 levels of probability, respectively**

Table (4): General combining ability effects (gi) for arrays at two years.

FT	NLF	TSS%	FF	AFW	TFW(kg)	TFN	EFW (kg)	EFN	FS%	NB/P	PH (cm)	years	Parent
0.06	0.55**	-0.21**	-0.09	3.07	0.26	-30.02	0.52	-8.87**	-0.81	1.04**	-11.45**	Y_1	P_1
0.26	0.14	-0.21**	-0.21**	3.89	1.38	-9.21	-0.32	-5.40**	-1.13	0.22	-4.45	Y_2	
-0.27	0.59**	-0.04	-0.11	0.08	-7.13**	-109.81**	-1.30**	-11.47**	-2.46**	1.28**	-4.77	Y_1	P_2
0.03	0.47	-0.03	-0.14*	2.51	-3.90**	-59.95**	-0.54	-7.49**	-1.43	1.59**	-2.31	Y_2	
-0.02	0.01	0.07	0.11	3.38*	-2.30*	-64.07*	0.17	-6.33*	1.76**	-0.16	-7.97**	Y_1	P_3
0.02	0.87**	0.17**	0.09	2.36	1.26	-4.67	0.56	0.08	2.13**	-0.22	-7.70**	Y_2	
0.05	0.35*	-0.17**	-0.02	4.05*	0.51	-25.86	1.61**	18.82**	-0.88*	-0.73*	6.45*	Y_1	P_4
-0.23	0.12	-0.11*	0.03	-4.54	-0.66	14.85	0.61	0.76	-0.12	-0.90*	2.26	Y_2	
-0.37*	-0.68**	0.24**	0.00	-20.62**	9.76**	316.98**	-1.81**	12.68**	1.64**	-1.59**	29.42**	Y_1	P_5
-0.39*	-0.58*	0.33**	0.04	-8.69	2.79**	91.30**	- 0.81	11.27**	3.63**	-0.86*	19.41**	Y_2	
0.55**	-0.82**	0.11*	0.11	10.03**	-1.10	-87.21**	0.80*	-4.83	0.75	0.16	-11.68**	Y_1	P_6
0.32	-1.01**	-0.15**	0.18*	4.47	-0.86	-32.32*	0.51	0.76	-3.07**	0.16	-7.21*	Y_2	
0.16	0.16	0.05	0.06	1.59	1.24	27.59	0.39	2.71	0.43	0.29	2.70	Y_1	SE
0.16	0.26	0.05	0.07	1.85	0.81	12.85	0.25	1.32	0.75	0.38	2.73	Y_2	

Table1 (6): Specific combining ability effects (Sij) of each cross for vegetative (PH – NB/P), flowering (FS %), earliness (EFN - EFW), total yield (TNF - TFW) and fruit quality (AFW – FF – TSS % - FT) traits at two years.

FT	NLF	TSS%	FF	AFW	TFW (kg)	TFN	EFW (kg)	EFN	FS%	NB/P	PH (cm)		Crosses
0.16	-0.88*	0.17	-0.03	-3.71	3.36	64.07	1.34	10.40	1.55	0.15	14.96*	Y_1	P_1 x P_2
0.515	-0.831	0.204	0.131	-0.226	2.293	29.578	-0.205	-2.504	0.928	-1.549	7.247	Y_2	
0.41	-0.22	0.01	0.10	-4.67	-4.44	-29.44	1.53	10.16	1.12	-0.48	-4.95	Y_1	P_1 x P_3
0.727	-0.869	0.001	0.141	-2.409	-1.555	-0.250	-0.219	-2.408	-1.133	1.762	3.238	Y_2	
-0.07	0.80*	-0.15	-0.18	4.94	1.35	-27.58	-1.35	-41.96**	3.36**	2.13**	-5.00	Y_1	P_1 x P_4
0.298	0.896	-0.104	-0.072	12.627**	3.090	-26.830	1.088	5.390	-2.882	-0.556	-2.922	Y_2	
0.14	-0.81*	0.15	0.23	-3.45	7.97**	133.38*	-1.01	1.14	1.68	3.77**	22.86**	Y_1	P_1 x P_5
-0.057	-0.900	0.151	0.098	6.324	1.927	-25.766	0.097	6.869*	1.365	3.404**	15.016*	Y_2	
0.76*	-0.92*	0.14	0.30*	-4.09	5.55	77.49	2.85**	36.02**	0.95	0.49	-20.70**	Y_1	P_1 x P_6
0.755*	-0.840	0.064	0.222	-10.540*	0.243	54.480	0.471	4.238	3.464*	1.087	-9.150	Y_2	
-0.27	-0.39	-0.04	0.53**	-4.32	1.93	52.45	0.01	-0.02	3.65**	3.69**	-14.48*	Y_1	P_2 x P_3
0.290	-0.903	-0.009	0.267	4.828	5.656**	44.933	0.339	2.329	1.165	1.786*	-8.697	Y_2	
0.88*	-0.74	0.14	-0.03	-0.81	8.81**	102.13	-0.51	20.57**	2.23*	1.25	-17.46**	Y_1	P_2 x P_4
0.817*	-1.353*	0.217	-0.071	-9.101*	6.103**	123.91**	0.861	5.340	-1.583	0.668	-2.824	Y_2	
0.63	-0.62	0.06	-0.26	5.76	5.85*	-10.57	-1.54	-32.17**	-1.08	-0.35	-0.12	Y_1	P_2 x P_5
0.689	0.345	0.052	-0.221	-2.651	-3.225	-46.985	0.033	3.611	-3.332	2.680**	3.242	Y_2	
-0.07	-0.70	-0.19	0.01	1.98	3.43	42.27	3.42**	15.15*	1.70	1.45*	22.79**	Y1	P_2 x P_6
-0.205	-0.222	-0.235*	0.011	5.801	4.426*	24.616	1.064	4.448	9.361**	1.462	9.608	Y2	
0.06	-1.12**	0.16	0.15	4.76	0.11	-33.21	0.22	-7.55	-2.11*	0.41	16.94**	Y_1	P_3 x P_4
0.219	-1.095	0.154	0.157	-2.364	1.816	36.947	0.970	5.756	8.849**	0.881	2.612	Y_2	
1.54**	-0.67	0.12	-0.13	-0.37	11.23**	127.48*	0.35	15.98*	3.24**	-0.19	2.10	Y_1	P_3 x P_5
0.711	-1.066	-0.001	-0.104	21.774**	6.709**	-51.998	0.108	7.035*	2.102	-0.456	-0.438	Y_2	
0.03	-0.45	-0.07	0.20	1.53	9.71**	95.48	-1.37	-6.67	1.05	1.40*	8.47	Y_1	P_3 x P_6
0.136	-0.303	0.181	0.180	-6.300	2.667	62.929	1.050	4.804	-4.194*	0.225	1.411	Y_2	
-0.29	0.27	-0.20	0.38**	-11.14**	2.53	155.59*	4.61**	112.28**	-2.83**	-0.92	21.40**	Y_1	P_4 x P_5
-0.080	1.219*	-0.245*	0.356*	-5.066	0.080	39.126	-0.485	-2.407	-0.646	2.124*	8.594	Y_2	
1.85**	-0.16	0.32**	0.07	2.75	-3.21	-51.68	-3.81**	-33.33**	-0.25	1.26	0.66	Y_1	P_4 x P_6
0.242	-0.307	0.237*	0.200	14.438**	1.735	-50.512	-1.083	-3.249	0.054	2.155*	-0.961	Y_2	
-0.06	0.68	-0.04	0.04	-1.57	3.84	-6.01	-0.92	-9.00	3.47**	0.62	18.16**	Y_1	P_5 x P_6
0.739*	0.362	0.222	0.226	-5.410	1.551	35.744	-0.002	6.596*	5.301**	0.269	20.306**	Y_2	
0.35	0.37	0.11	0.14	3.62	2.81	62.57	0.88	6.15	0.98	0.65	6.11	Y_1	SE
0.3617	0.5982	0.1130	0.1518	4.2066	1.8322	29.1300	0.5763	3.0021	1.6967	0.8721	6.1914	Y_2	

***, ** Significant at 0.05 and 0.01 levels of probability, respectively**

(1) Castel Rock (2) Edkawy (3) Super Marmand

(4) Flora-dad (5) B5357 (6) Fline

Table (7): Specific combining ability effects (Sij) of each cross for vegetative (PH – NB/P), flowering (FS %), earliness (EFN - EFW), total yield (TNF - TFW) and fruit quality (AFW – FF – TSS % -NLF- FT) traits from the combined data over both years.

FT	NLF	TSS%	FF	AFW	TFW (kg)	TFN	EFW (kg)	EFN	FS%	NB/P	PH (cm)	Crosses
0.338	-0.854*	0.185	0.051	-1.970	2.828	46.822	0.569	3.948	1.237	-0.698	11.104	P_1 x P_2
0.570*	-0.544	0.004	0.122	-3.541	-2.996	-14.844	0.656	3.877	-0.008	0.641	-0.855	P_1 x P_3
0.116	0.846*	-0.127	-0.126	8.784**	2.218	-27.207	-0.129	-18.287**	0.238	0.787	-3.961	P_1 x P_4
0.039	-0.853*	0.152	0.163	1.436	4.949**	53.807	-0.458	4.003	1.524	3.585**	18.940**	P_1 x P_5
0.755**	-0.881*	0.100	0.263*	-7.316*	2.898	65.985	1.659**	20.131**	2.208*	0.788	-14.928**	P_1 x P_6
0.012	-0.645	-0.026	0.399**	0.253	3.791*	48.689	0.174	1.153	2.408*	2.739**	-11.591**	P_2 x P_3
0.851**	-1.047**	0.179*	-0.050	-4.955	7.459**	113.023**	0.176	12.957**	0.326	0.961	-10.143*	P_2 x P_4
0.658*	-0.137	0.056	-0.243*	1.555	1.315	-28.780	-0.756	-14.280**	-2.208*	1.165*	1.563	P_2 x P_5
-0.138	-0.463	-0.211*	0.008	3.889	3.927*	33.444	2.240**	9.799**	5.532**	1.457**	16.200**	P_2 x P_6
0.141	-1.106**	0.159	0.155	1.199	0.963	1.867	0.594	-0.895	3.371**	0.646	9.777*	P_3 x P_4
1.125**	-0.866*	0.060	-0.117	10.701	8.970**	37.741	0.231	11.507**	2.670**	-0.323	0.831	P_3 x P_5
0.083	-0.376	0.054	0.192	-2.386	6.189**	79.203*	-0.160	-0.933	-1.574	0.812	4.939	P_3 x P_6
-0.184	0.743*	-0.222**	0.368**	-8.103**	1.306	97.359**	2.064**	54.939**	-1.737	0.603	14.995**	P_4 x P_5
1.047**	-0.232	0.279**	0.134	8.596**	-0.738	-51.094	-2.448**	-18.287**	-0.100	1.707*	-0.150	P_4 x P_6
0.340	0.523	0.089	0.135	-3.489	2.697	14.869	-0.459	-1.204	4.38**	0.443	19.233**	P_5 x P_6
0.2528	0.3520	0.0798	0.1029	2.7736	1.6788	34.5071	0.5259	3.4241	0.9793	0.5447	4.3501	SE

***, ** Significant at 0.05 and 0.01 levels of probability, respectively**
(1) Castel Rock (2) Edkawy (3) Super Marmand
(4) Flora-dad (5) B5357 (6) Fline

❖