

## **INHERITANCE OF SOME IMPORTANT TRAITS IN SWEET PEPPER (*Capsicum annuum* L.)**

**Mahmoud, I. M.**

**Plant Production Department (Vegetable). Fac. Environ. Agric. Sci.,  
El-Arish, Suez Canal Univ., Egypt**

### **ABSTRACT**

The present study was conducted at the Experimental Farm, Faculty of Environmental Agricultural Sciences, El Arish, Suez Canal University, Egypt, during three successive summer seasons from 2011 to 2013. The study involved six generations; viz., P<sub>1</sub>, P<sub>2</sub>, F<sub>1</sub>, F<sub>2</sub>, Bc<sub>1</sub> and Bc<sub>2</sub> of sweet pepper hybrid (B10-24 x TS 6-3-3). The objective of the present investigation was to study the inheritance of some important traits of sweet pepper. The obtained results showed that difference between the two parents was highly significant for all studied traits. The means of F<sub>1</sub> cross was deviated toward the high parent for most characters, while it was similar to that of high parent for average fruit weight. Segregating populations showed greater coefficient of variability (C.V%) than the non-segregating ones for all studied traits. Additive gene effects (d) were significant in the inheritance of all characters, except fruit length, fruit diameter and pericarp thickness. However, dominance gene action (h) was more importance in the inheritance of all studied traits, except number of fruits/plant. Epistasis gene actions were found to be important in the inheritance of most traits. Heterosis over mid-parents was detected in eight characters. However, heterosis over better parent was found, but only in three traits. Inbreeding depression was observed in six characters. Heritability estimates in broad sense (h<sub>b</sub>) were high for all characters. The minimum number of genes controlling the traits were one pair for plant height, fruit diameter, pericarp thickness, T.S.S, ascorbic acid and total yield/plant, while number of genes were estimated as two to three pairs for number of branches, two to four for fruit length, three to seven for number of fruits/plant and two pairs for average fruit weight.

### **INTRODUCTION**

Sweet pepper (*Capsicum annuum* L.) is one of the important vegetable crops in Egypt, it is grown in many locations and different seasons. It's obviously in a recent years high productivity and quality are needed to meet the increasing demand. One effort to improve pepper production and quality is a breeding program. The program is aimed at the use of superior varieties and hybrids with high yields and good qualities that can be accepted by farmers (Kusandriani and Permadi, 1996). However, efforts to improve the crop have been constrained mainly by a lack of adequate information on the genetic and inheritanceplant characteristics. For varietal improvement, the potential of the base populations and selection efficiency can be investigated by evaluating the relative importance of the additive and non-additive effects in determining each important trait and by choosing the breeding procedures which could maximize genetic gains.

The explanation for the relative importance of additive and non-additive gene effects in planning more efficient breeding programs could be obtained from a comparative assessment of the liner component; viz.,

additive (d), dominance (h), additive x additive(i), dominance x dominance (l) and additive x dominance (j) gene effects (Jadhav and Dhupal, 1994).

With respect to studies on gene effects, the non-additive gene effects play the main role in the inheritance of number of branches (Joshi, 1988). The three types of gene action were important in the inheritance of plant height, total fruit number and average fruit weight (Khalil *et al.*, 1989b). Mohamed *et al.* (1995) found various types of gene action as, additive and epistasis (addi. x dom. and dom. x dom.) for total fruit number, additive and non-additive for total fruit weight, additive and dominance for average fruit weight. Khereba *et al.* (1995) reported that dominance and non-allelic interaction were important for fruit length, while additive and epistasis for fruit diameter. In another study, Hasanuzzaman and Golam (2011) found that additive, dominance and epistasis were more important for fruit number and total yield/plant. Dominance genetic variance appeared to be important for TSS% (Ibrahim, 2007). Meanwhile Khalil *et al.*, (1989b) found additive and dominance x dominance for this trait, also Hatem and Salem (2009) found dominance x dominance was important for TSS%. Heterosis over mid-parents and better parent were studied and detected by Farag (2000) and Gouda *et al.* (2003) for plant height, Ahmed *et al.* (1998) for number of branches and Depestre and Espinos (1988) and Mishra *et al.* (1988) for total yield. Heterosis over mid-parents was observed by Khalil *et al.* (1989a) for average fruit weight, while Khalil-Allah *et al.* (1975) showed that the small fruits were partially dominant over the large fruit. The most F<sub>1</sub> crosses produced longer fruits than their mid parents (Kumar and Lai, 2001 and Hasanuzzaman and Golam, 2011). Hybrid vigour was observed in many fruit quality; viz., V.C and TSS% (Ibrahim, 2007 and Khalil and Hatem, 2014). Heritability in broad sense was high for plant height, number of branches, average fruit weight, fruit length and total yield (Chu, 1995), total fruit number and average fruit weight (Legg and Lippert, 1966). However, heritability in narrow sense was high for plant height and number of branches (Chu, 1995), average fruit weight, fruit length, fruit diameter and pericarp thickness (Ben-Chaim and Paran, 2000 and Syukur *et al.*, 2010) and V.C and TSS% (Farag, 2000), while it was low for total fruit number and total yield (Chu, 1995).

The minimum number of genes controlling the traits of pepper was one pair for plant height and total fruit number (Khalil, 2013) and total yield, fruit length, fruit diameter and average fruit weight (Syukur *et al.*, 2010), while it was two pairs of genes for average fruit weight (Khalil, 2013) and fruit length (Khareba *et al.*, 1995). Also it was ranged from two to three pairs for total fruit yield and V.C content (Hatem and Salem, 2009), three to four pairs for total fruit number, one to two pairs for average fruit weight, one to three pairs for total yield (Mohamd *et al.*, 1995) and three to four pairs for fruit diameter (Khareba *et al.*, 1995). Therefore, the present investigation was undertaken aiming to study the inheritance of some important characters of sweet pepper.

## MATERIALS AND METHODS

The present study was conducted at the Experimental Farm, Faculty of Environmental Agricultural Sciences, El Arish, Suez Canal University, Egypt, during three successive summer seasons from 2011 to 2013. The study involved six generations; viz., P<sub>1</sub>, P<sub>2</sub>, F<sub>1</sub>, F<sub>2</sub>, Bc<sub>1</sub> and Bc<sub>2</sub> of the sweet pepper hybrid (B10-24 x TS 6-3-3), the two parental lines were widely different in their characteristics. The seeds of parents were obtained from Veg. Res. Dep., Hort. Res. Inst., Agric. Res. Center, Giza, Egypt (Kansouh, 2007). In the first season 2011 the seeds were sown on January 1<sup>st</sup> in speeding trays and the seedlings were transplanted on March 1<sup>st</sup> and the crossing was made between the two parents to produce F<sub>1</sub> seeds. In the second season 2012, seeds of F<sub>1</sub> hybrid and their parents were planted, the F<sub>1</sub> plants were selfed to produce F<sub>2</sub> seeds and at the same time backcrossed to both parents to produce Bc<sub>1</sub> and Bc<sub>2</sub>.

The six populations; viz., P<sub>1</sub>, P<sub>2</sub>, F<sub>1</sub>, F<sub>2</sub>, Bc<sub>1</sub> and Bc<sub>2</sub> were evaluated in the third season 2013 under open field conditions and the transplanting was done on March 1<sup>st</sup>. The populations were grown in a randomized complete block design, with three replications. Each replicate consisted of 12 rows: one row for non-segregation generation (P<sub>1</sub>, P<sub>2</sub> and F<sub>1</sub>), three rows for each backcross and five rows for the F<sub>2</sub> populations. Each row was 7m long and 1m wide, and contained 14 plants. The total number of plants included in the study was 630 distributed among the six generations as follows: 42 of each homogenous population (P<sub>1</sub>, P<sub>2</sub> and F<sub>1</sub>), 252 of F<sub>2</sub> and 126 of each backcross. Dripper lines were used and spaced 1m between each to other.

Data recorded: Data were recorded on individual plants basis from all populations. The characters studied were: plant height and number of branches/plant (after 100 days from transplanting). At the third harvest, at the green mature stage, fruit length (cm), fruit diameter (cm) and pericarp thickness (mm) were measured. Ascorbic acid content was determined according to A.O.A.C. (1975) and total soluble solids (T.S.S%) was determined by a hand refractometer. Total yield/plant (kg) and total number of fruits/plant of all harvested fruits from each plant were recorded. Average fruit weight (g) was calculated by dividing total weight of all harvested fruits over total number of fruits/plant. Conventional culture practices were done as needed in commercial pepper production in the open field in North Sinai region.

**Statistical and genetic analysis:** Data were statistically analyzed, and T-test was used to test the significance of differences among the various means.

- Arithmetic mean: The formula used for calculation of the arithmetic mean for the different populations were reported by Powers *et al.* (1950).
- Scaling tests 1: The scaling test provides information regarding absence or presence of gene interactions according to the formula of Mather (1949).
- Component of generation means: Six parameters models for estimation various genetic components were used according to Hayman (1958).
- Heterosis percentage: Heterosis over mid-parents (M.P) and better parent (B.P) were determined according to Mather and Jinks (1971) formulae.

- Potence ratio (P) was estimated according to Smith (1952).
- Average degree of dominance was calculated as follows  $(H/D)^{1/2}$  where, H and D are dominance and additive variances, respectively.
- Inbreeding depression (I.D.) %, was calculated as follows =  $(F_1 - F_2)/F_1 \times 100$ , where  $F_1$  and  $F_2$  are the mean of  $F_1$  and  $F_2$  generations, respectively.
- Heritability: Heritability in broad ( $h_b$ ) and narrow ( $h_n$ ) sense were calculated using the equations of Falconer (1981) and Mather and Jinks (1982), respectively.
- Predicted gain under selection ( $\Delta G$ ): It was calculated as given by Johanson *et al.* (1955).
- Genetic advance under selection ( $\Delta G\%$ ): It was estimated according to Miller *et al.* (1958).
- The minimum number of genes controlling the difference between parents was estimated according to Castle-Wright (1921) and Mather and Jinks (1977).

## **RESULTS AND DISCUSSION**

### **1. Mean performance of the studied populations**

The mean values of ten characters in the six populations of the cross (B-10-24 x TS-6-3-3) are shown in Table 1. The obtained results showed that the differences between the two parents were highly significant for all studied traits. Accordingly, genetic differences probable and the genetic studies could be continued for all characters.

The data revealed that the line TS-6-3-3 surpassed B-10-24 in all studied traits, except fruit diameter the line B-10-24 gave the highest value than the other parent.

The means of  $F_1$  cross were deviated toward the high parent (Table 1) for number of branches, fruit length, number of fruits/plant, ascorbic acid and TSS % content, indicating partial dominance. These results were supported by the estimated potence ratio, which was less than unity and by estimated heterosis over mid-parents for these traits (Table 4). Similar results were obtained by Mohamed *et al.* (1995), Khereba *et al.* (1995), Farag (2000) and Doshi (2003) who reported partial dominance for these traits.

Also, the mean of  $F_1$  was similar to that of high parent for average fruit weight, indicating complete dominance to the heavier fruit. The mean of  $F_1$  was exceeded than the better parent in plant height, pericarp thickness and total yield/plant, indicating over dominance for the high parent. The estimated potence ratio confirmed these results, which was more than one (Table 4). Over dominance toward the high parent was observed by Gaffar (1993) and Mohamed *et al.* (1995) for these traits.

Over dominance toward the low parent was observed for fruit diameter where  $F_1$  mean was less than the low parent, this conclusion is supported by the estimated potence ratio (Table 4) which was more than unity with negative sign. The results are agreed with Khalil *et al.* (1989a), Gaffar (1993) and Khereba *et al.* (1995) for fruit diameter.



Concerning  $F_2$  generations, the means of  $F_2$  decreased from their respective  $F_1$  means for all studied traits, except pericarp thickness. This could be due to inbreeding depression (Table 4), because the superiority of  $F_1$  plants could be due to an accumulation of favorable dominant alleles.

Differences between means of  $Bc_1$  and  $Bc_2$  were observed for all studied traits, this may be due to increasing alleles associated with parent and decreasing in the other parent. The means of  $Bc_1$  and  $Bc_2$  were higher than the means of  $F_2$  populations for fruit length and diameter. Generally, in all traits the means of backcross to the higher parent exceeded the means of backcross to low parent, except pericarp thickness and fruit diameter as expected.

Variances of the non-segregating populations; viz.,  $P_1$ ,  $P_2$  and  $F_1$  differed. However, they were the least variable comparing with the segregating populations; viz.,  $F_2$ ,  $Bc_1$  and  $Bc_2$  for all studied traits, this indicates that they were more homogenous than the  $F_2$  and both backcross populations, which showed greater coefficient of variability (C.V%) as presented in Table 1. These results were expected because the segregating populations consisted of homozygous and heterozygous plants. Moreover, the results indicated the existence of both genetic and environmental variation affecting these traits. Similar results were observed by many investigators among them Khareba *et al.* (1995), Mohamed *et al.* (1995) and Khalil (2013).

The comparison between the observed and arithmetic means of all populations (Table 1) revealed significant or highly significant differences for T.S.S %, ascorbic acid, total yield/plant, number of fruits /plant and average fruit weight, indicating the presence of dominance. While, no significant differences were observed for the remaining traits in all populations, indicating no dominance or additive gene effects.

## **2. Scaling test**

The purpose of scaling test, A, B and C are to determine the adequacy of additive-dominance model for studying types of gene action in the inheritance of different traits.

Data in Table 2 show that one or more of the three scales were significant or highly significant for all traits under study, indicating the presence of non-allelic interaction, and the simple additive-dominance model are insufficient to explain the inheritance of studied traits.

## **3. Components of generation means**

The six parameters model of Hyman (1958) was used for further test of the absence or presence and nature of non-allelic gene interaction through the parameters against the respective standard errors following a conventional (t) test. The type of gene effects for the studied traits in the cross B-10-24 x TS-6-3-3 are given in Table 3. Data show that one or more of gene effects were significant or highly significant. Therefore, additive-dominance model is adequate to interpret gene effects for these traits.

Mean effects of parameter (m) that reflects the contribution due to the overall mean plus the locus effects and interaction of the fixed loci for the previous traits, the mean values ranged from 0.285 to 109.504 for pericarp thickness and ascorbic acid, respectively.



Additive gene effects (d) were significant in the inheritance of all characters under study, except fruit length, fruit diameter and pericarp thickness, since the additive gene actions were not significant. Similar results were observed by Khalil *et al.* (1989b) and Doshi (2003).

All studied traits were controlled by dominance gene action (h), except number of fruits/plant, indicating the importance of dominance in the inheritance of these traits. Many investigators reported similar results, among them Jadhav and Dhumal (1994), Mohamed *et al.* (1995) and Ibrahim (2007).

Regarding additive x additive types of epistasis (i) gene action, they were found to be important in the inheritance of most studied traits, i.e., plant height, fruit length, fruit diameter, pericarp thickness, ascorbic acid, total yield /plant and average fruit weight (Table 3).

Epistasis gene actions of additive x dominance (j) also were important in the inheritance of all studied traits, except plant height which (j) had non - significant value.

With regard to dominance x dominance (l) epistasis gene actions, they were found to be highly significant for all traits, except ascorbic acid, total yield/plant and average fruit weight, indicating the importance of (l) in the inheritance of these traits (Table 3). The results of epistasis gene action are in conformity with those of Joshi (1988), Khalil *et al.* (1989b), Khereba *et al.* (1995), Ahmed *et al.* (1998), Hatem and Salem (2009) and Hasanuzzaman and Golam (2011).

Generally, the results of the present investigation indicated the presence of both additive and non-additive gene actions in all studied traits, suggesting the importance of both selection and heterosis breeding in improving these traits. Also, results indicate that the presence of gene effects additive, dominance and non-allelic interaction (i) in other characters, indicate that, these types of gene effects played major important role in the inheritance of these traits.

#### **4. Genetic components**

Heterosis and inbreeding depression were estimated, the data of Table 4 show that heterosis over mid-parents was highly significant with positive values for eight characters. The values ranged from 2.13% to 56.79% for ascorbic acid and total yield/plant, respectively. Also, heterosis over better parent was detected with positive and highly significant values in three traits (plant height, pericarp thickness and total yield). Many researchers found similar results among them Khalif-Allah *et al.* (1975), Depester and Espinos (1988), Mishra *et al.* (1988), Khalil *et al.* (1989a), Ahmed *et al.* (1998), Farag (2000), Kumar and Lai (2001), Gouda *et al.* (2003), Hasanuzzaman and Golam (2011) and Khalil and Hatem (2014). While, heterosis over both mid-parents and better parent was not significant or had negative values for the other traits under study.

In all studied traits the  $F_1$  means exceeded the respective  $F_2$  means, except pericarp thickness, indicating inbreeding depression in these traits. Inbreeding depression was positive and highly significant for plant height, number of branches, fruit length, fruit diameter, T.S.S. % and total yield /plant. Similar results were found by Todorov (1995) and Ibrahim (2007). While inbreeding depression was absent for the other traits.

Inbreeding depression measured the reduction in performance of the  $F_2$  generation due to inbreeding. The large amount of inbreeding depression was



observed for fruit length (39.54%), total yield/plant (30.11%), number of branches/plant (29.22%) and plant height (27.89%) as expected since these traits showed large amount of heterosis. The high level of heterosis and inbreeding depression present in this study was an evidence of the relative importance of dominance gene effects in these materials. Therefore, dominance should give the more attention in any program of breeding for heterosis in the future.

The amount of dominance effects can be seen from the value  $(H/D)^{1/2}$ . The value  $(H/D)^{1/2}$  was less than one (0.94) for pericarp thickness, indicating partial dominance, while it was more than one for the other traits, indicating over dominance (Table 4).

Heritability in both broad and narrow senses are very important and should be recognized as a first step before starting any breeding program. Data presented in Table 4 show that heritability estimates in broad sense ( $h_b$ ) were high for all characters under study, indicating lesser influence of the environment. Many researchers found high values of heritability in broad sense for most studied traits (Legg and Lippert, 1966; Chu, 1995; Ben-Chaim and Paran, 2000; Syukur *et al.*, 2010 and Khalil, 2013).

The estimated values of narrow sense heritability ( $h_n$ ) were higher for pericarp thickness (65.09) and T.S.S % (51.33), these results agree with those obtained by Farag (2000). However, it was moderate for plant height (47.08), average fruit weight (43.06) ascorbic acid (41.39), fruit length (40.85) number of branches (36.68), fruit number (36.63), total yield (36.29) and fruit diameter (31.85). These were in parallel with those of Ben-Chaim and Paran (2000) and Farag (2000). This could be attributed to that most of the genetic variance was mainly due to additive gene action. As well as, if the estimated value of heritability is high, the selection is done in the early generations. So, the development program for these traits could be done through a selection method.

The values of expected genetic advance ( $\Delta G\%$ ) under selection when the top 5% of  $F_2$  plants are selected were high for all studied traits, except ascorbic acid which was low. However, the expected genetic advance ranged from 4.93% to 49.18% for ascorbic acid and pericarp thickness, respectively (Table 4). Similar trend was observed by Khalil (2013) for plant height, average fruit weight and total fruit number/plant.

The predicted gain ( $\Delta G$ ) from selection using individual plant of the best 5 percent of the  $F_2$  plants differ from trait to other (Table 4), it was high for average fruit weight (13.46), plant height (6.85), ascorbic acid (5.40) and number of fruits (3.50), however it was low for the remaining traits.



The minimum number of genes controlling the traits are presented in Table 4, using two equations of Castle-Wright (1921) and Mather and Jinks (1977) showed that there was one pair of genes controlling each of the following traits, plant height, fruit diameter, pericarp thickness, T.S.S, ascorbic acid and total yield/plant based on both equations. These results agreed with those of Hatem and Salem (2009) and Khalil (2013). Using Castle-Wright and Mather and Jinks formulae the number of genes were estimated as 1.18 and 2.61 for number of branches, 1.86 and 3.50 for fruit length, 2.90 and 6.57 for number of fruits/plant and 1.06 and 2.0 for average fruit weight, respectively. Similar results were obtained by many researchers, Mohamed *et al.* (1995) for total fruit number, Khereba *et al.* (1995) for fruit length and Khalil (2013) for average fruit weight. These results indicated that minimum number of genes controlling the difference between the two parents were estimated as two to three pairs for number of branches, two to four for fruit length, three to seven for number of fruits/plant and two pairs for average fruit weight.

## REFERENCES

- Ahmed, N.; F.A. Shah; G.H. Zargar and S.A. Wani (1998). Line x Tester analysis for the study of combining ability in hot pepper (*Capsicum annuum* L.). *Capsicum and Eggplant Newsletter*, No. (17): 38-41.
- A.O.A.C. (1975). Association of Official Agricultural Chemists. Official Methods of Analytical Chemists. 12<sup>th</sup> ed. Washington, D.C., U.S.A
- Ben-Chaim, A. and I. Paran (2000). Genetic analysis of quantitative traits in pepper (*Capsicum annuum* L.). *J. Amer. Soci. Hort. Sci.* 125: 66-70.
- Castle, W.E. and S. Wright (1921). An improved method of estimating the number of genetic factors concerned in cases of blending inheritance. *Sci.* 54:223.
- Chu, Z.Q. (1995). Studies on genetic parameters of main characters of hot pepper and application to breeding. *Acta Hort.* 402: 293-298.
- Depestre, T. and J. Espinosa (1988). Study of the effect of heterosis in pepper (*Capsicum annuum* L.). *Agrotenia de Cuba.* 20: 87-90. [C.F. *Plant. Breed. Abstr.* 59: 4334].
- Doshi, K.M. (2003). Genetic architecture of chilli (*Capsicum annuum* L.). *Capsicum and Eggplant Newsletter*, No.(22): 33-36.
- Falconer, D. S. (1981). Introduction to quantitative genetics. Longman, London. P. 340.
- Farag, S.T. (2000). Breeding and genetical studies for some traits in pepper. Ph. D. Thesis, Fac. Agric. Minoufiya Univ. Egypt.
- Gaffar, M.S.A. (1993). Studies on some genetical and physiological characteristics in pepper. M.Sc. Thesis, Fac. Agric., Ain Shams Univ. Egypt.
- Gouda, L.; R. Mulge and M.B. Madalageri (2003). Capsicum x chilli crosses: Heterosis and combining ability for growth parameters. *Indian J. Hort. Sci.* 60: 262-267.

- Hasanuzzaman, M. and F. Golam (2011). Gene actions involved in yield and yield contributing traits of chilli (*Capsicum annuum* L.). *Austr. J. Crop Sci.* 5(13):1868-1875.
- Hatem, M. K. and A. A. Salem (2009). Genetic studies of some characters in sweet pepper (*Capsicum annuum*L.). *Minufiya J. Agric. Res.* 34(1):163-176.
- Hayman, B.I. (1958). The separation of epistasis from additive and dominance variation in generation means. *Heredity.* 12:371-390.
- Ibrahim, K.Y. (2007). Studies on producing of hybrids pepper (*Capsicum annuum*L.). Ph.D. Thesis, Fac. Agric. Mansoura Univ. Egypt.
- Jadhav M.G. and S.A. Dhumal (1994) Genetic studies of some quantitative characters in chilli. *Journal of Maharashtra Agric.University*19(1):62-64.
- Johanson, H.W.; H. F. Robinson and R. E. Comstok (1955). Estimates of genetic and environmental variability in soybeans. *Agric.J.* 47: 314-318.
- Joshi, S. (1988). Results of genetic analysis in sweet pepper (*Capsicum annuum* L.). *Capsicum and Eggplant Newsletter*, No.(7): 35-36.
- Kansouh, A.M. (2007). Developing new lines of sweet pepper by selection. *Egypt. J. Appl. Sci.*, 25(5A): 158-174.
- Khalf-Allah, A.M.; Z.E. Abdel-Al and A.A. Gad (1975). Inheritance and gene action for yield in peppers (*Capsicum annuum* L.). *Egypt. J. Genet. Cytol.* 4(2): 287-296.
- Khalil, Mona R. (2013). The genetic behaviour of some important characters in sweet pepper (*Capsicum annuum* L.). *Egypt. J. plant breed.*17: (2).
- Khalil, Mona R. and M. K. Hatem (2014). Study on combining ability and heterosis of yield and its components in pepper (*Capsicum annuum* L.). *Alex. J. Agric. Res.* 59 (1): 61-71.
- Khalil, R.M.; N.M. Malash; and A.M. Kansouh (1989a). Degree of heterosis, based on the mid-parents, for some characters in pepper. *Minufiya. J. Agric. Res.* 14: 1025-1040.
- Khalil, R.M.; N.M. Malash and A.M. Kansouh (1989b). Studies on gene action for some quantitative characters in pepper (*Capsicum annuum*L.). *Minufiya. J. Agric. Res.* 14: 969-981.
- Khereba, A.H.; M.A. Mohamed; S.A. Mohamadin and M.H. Zaky (1995). Genetical studies on sweet pepper: II-Inheritance of some fruit characters in pepper. *Egypt. J. Hort. Sci.* 22: 65-79.
- Kumar, R. and G. Lai (2001). Expression of heterosis in hot pepper (*Capsicum annuum*L.). *Capsicum and Eggplant Newsletter*, No. (20): 38-41.
- Kusandriani Y. and A. H. Permadi (1996). Pemuliaan tanaman cabai. In: Duriat AS, Hadisoeganda AWW, Soetiarso TA, Prabaningrum L (eds). *Teknologi produksi cabai merah*. Lembang: Balai Penelitian Sayuran. ( C. F. Syukur et al., 2010, *Hayati J. Biosci.* 17 (4):183-188).
- Legg, P.D. and L.F. Lippert (1966). Estimates of genetic and environmental variability in a cross between two strains of pepper (*Capsicum annuum*L.). *Amer. Soci. Hort. Sci.* 89: 443-448.
- Mather, K. (1949). *Biometrical genetics*. 1<sup>st</sup> ed. Methuen, London.
- Mather, K. and J.L. Jinks (1971). *Biometrical genetics*. 2nd ed. Chapman and Hall, LTD. London, p. 382.

- Mather, K. and J.L. Jinks (1977). Introduction to biometrical genetics. Chapman and Hall, London, p. 231.
- Mather, K. and J.L.Jinks (1982). Biometrical genetics. 3rd ed. Chapman and Hall, London.
- Miller, R.A.; J.C. Williams; H.F. Robinson and R.E. Comstock (1958). Estimates of genotypic and environmental variances and covariances in upland cotton and their implications in selection. Agron. J. 50: 126-131.
- Mishra, R.S.; R.E. Lotha; S.N. Mishra; P.X. Paul and H.N. Mishra (1988). Results of heterosis breeding on chilli (*Capsicum annuum* L.). Capsicum and Eggplant Newsletter, No.(7): 49-50.
- Mohamed, M.A.; A.H. Khareba; E. Abo-EL-Hassan and M.H. Zaky (1995). Genetical studies on sweet pepper: I-Genetic behaviour of yield character. Egypt. J. Hort. Sci. 22: 49-64.
- Powers, I.; F. Loke and J.C. Garrett (1955). Partitioning method of genetic analysis applied to quantitative characters of tomato crosses. U.S. Dept. Agric. Tech. Bull., P. 998.
- Smith, H.H. (1952). Fixing transgressive vigour in nicotiana. Heterosis Iowa State College Press, Ames, Iowa USA.
- Syukur, M.; S. Sujiprihati; R. Yuniarti and U. Dang (2010). Diallel analysis using Hayman method to study genetic parameters of yield components in pepper (*Capsicum annuum* L.). Hayati J. Biosci. 17(4):183-188.
- Todorov, J. (1995). Inheritance of the height of red pepper plants. EUCARPIA IX<sup>th</sup> Meeting on Genetics and Breeding on Capsicum and Eggplant, Budapest, Hungary. pp. 99-102.

### توريث بعض الصفات الهامة في الفلفل الحلو

محمود إبراهيم محمود

قسم الإنتاج النباتي (خضر) - كلية العلوم الزراعية البيئية بالعريش- جامعه قناة السويس - مصر

أجريت هذه الدراسة بمزرعة كلية العلوم الزراعية البيئية بالعريش- جامعه قناة السويس- مصر, خلال الموسم الصيفي في الفترة من ٢٠١١/٢٠١٣. استخدم في الدراسة سلالتان من الفلفل كآباء (بى ١٠-٢٤ , تى اس ٦-٣), حيث أجريت التهجينات بينهما للحصول على بذور الجيل الأول والثاني والتلقيحات الرجعية لكلا الأبوين بهدف دراسة توريث بعض الصفات الهامة في الفلفل الحلو. وكانت أهم النتائج المتحصل عليها ما يلي:-

وجدت اختلافات معنوية عالية بين الأبوين في كل الصفات المدروسة وأظهرت العشائر الانعزالية معامل اختلاف أكبر مما في العشائر الغيرانعزالية. أظهر الفعل الجيني المضيف معنوية في توريث معظم الصفات المدروسة, في حين تحكم الفعل الجيني السياتي في توريث كل الصفات المدروسة عدا عدد الثمار/ نبات. وظهرت قوة هجين بالنسبة لمتوسط الأبوين في ثمانى صفات, في حين لم تظهر قوة هجين بالنسبة للاب الافضل الا في ثلاث صفات.

كانت درجة التوريث على النطاق الواسع عالية لكل الصفات المدروسة, وكان عدد الجينات المتحكم في الصفات زوج واحد لصفات ارتفاع النبات, قطر الثمرة, سمك اللحم, % T.S.S, حامض الاسكوريك والمحصول الكلى/ نبات, وزوجين لصفة متوسط وزن الثمرة, في حين تراوح من زوجين الى ثلاثة ازواج لعدد الافرع / نبات, ومن زوجين الى اربعة ازواج لطول الثمرة ومن ثلاثة الى سبعة ازواج لعدد الثمار/ نبات.

**Table 2: Scaling test (A, B and C) and their standard errors for some important traits of sweet pepper for the cross (B-10-24 x TS-6-3-3).**

Characters	Scaling test		
	A	B	C
Plant height	-17.548±1.235**	-14.682±1.369**	-43.993±1.980**
No. of branches	-2.068±0.211**	-3.591±0.227**	-6.110±0.330**
Fruit length	-2.129±0.208**	-5.222±0.220**	-11.612±0.326**
Fruit diameter	0.295±0.147*	0.873±0.162**	-2.321±0.231**
Pericarp thickness	0.052±0.017**	-0.048±0.018*	0.175±0.029**
T.S.S %	-2.015±0.132**	-0.229±0.128	-2.342±0.201**
Ascorbic acid content	-14.039±131**	-6.866±1.283**	-35.701±1.880**
Total yield/plant	-0.723±0.077**	0.074±0.091	-0.916±0.127**
Number of fruit /plant	-10.984±0.967**	-0.462±0.946	-10.328±1.436**
Average fruit weight	-13.888±2.587**	5.765±3.335	-22.880±4.587**

**Table 3: Mean estimation of six parameter model of gene effects for some important traits of sweet pepper for the cross (B-10-24 x TS-6-3-3).**

Characters	Gene effects					
	m ± S.E	d ± S.E	h ± S.E	i ± S.E	j ± S.E	l ± S.E
Plant height	46.456±0.447**	-7.443±0.848**	25.759±2.500**	11.818±2.463**	-1.460±0.894	20.358±3.928**
No. of branches	4.760±0.066**	-0.689±0.130**	1.326±0.384**	0.451±0.372	0.761±0.146**	5.209±0.616**
Fruit length	5.015±0.062**	-0.114±0.120	5.015±0.362**	4.261±0.346**	1.547±0.142**	3.090±0.582**
Fruit diameter	3.191±0.045**	-0.057±0.090	2.488±0.266**	3.489±0.256**	-0.289±0.103**	-4.658±0.429**
Pericarp thickness	0.285±0.007**	0.016±0.012	-0.123±0.036**	-0.170±0.035**	0.050±0.012**	0.166±0.055**
T.S.S %	5.051±0.041**	-1.311±0.077**	0.461±0.234*	0.099±0.227	-0.893±0.087**	2.144±0.369**
Ascorbic acid content	109.504±0.400**	-7.670±0.774**	17.287±2.281**	14.795±2.228**	-3.586±0.847**	6.110±3.623
Total yield/plant	1.334±0.024**	-0.618±0.047**	0.959±0.141**	0.268±0.134*	-0.399±0.056**	0.381±0.227
Number of fruit /plant	29.468±0.293**	4.906±0.575**	-2.817±1.694	-1.117±1.642	-5.261±0.642**	12.563±2.712**
Average fruit weight	46.465±0.960**	-29.744±1.846**	33.086±5.472**	14.758±5.326**	-9.827±1.980**	-6.635±8.694

**Table 4: Estimation of genetic parameters for some important traits of sweet pepper for the cross (B-10-24 x TS-6-3-3).**

<b>Characters</b>	<b>Plant height</b>	<b>No. of branches</b>	<b>Fruit length</b>	<b>Fruit diameter</b>	<b>Pericarp thickness</b>	<b>T.S.S %</b>	<b>Ascorbic acid content</b>	<b>Total yield/plant</b>	<b>Number of fruits/plant</b>	<b>Average fruit weight</b>
<b>Genetic parameters</b>										
Heterosis (%)										
-Over mid parent (M.P)	27.62**	14.96**	10.00**	-23.45**	21.72**	6.65**	2.13**	56.79**	-5.17**	42.60**
-Over better parent (B.P)	14.09**	-7.88**	-9.85**	-27.39**	5.34**	-0.95**	-1.31*	32.86**	-27.55**	-2.52
Inbreeding depression(I.D%)	27.891**	29.219**	39.542**	2.427**	-7.573**	13.179**	8.499	30.113**	5.551	24.262
Potence ratio (PR)	2.33	0.60	0.45	-4.32	1.40	0.87	0.61	3.15	-0.17	0.92
Average degree of dominance (H/D) <sup>1/2</sup>	1.36	1.49	1.18	1.62	0.94	1.06	1.44	1.29	1.53	1.39
Heritability (%)										
-Broad sense	90.88	77.58	69.06	73.64	93.95	80.21	84.12	66.69	79.25	84.93
-Narrow sense	47.08	36.68	40.85	31.85	65.09	51.23	41.39	36.29	36.63	43.06
Genetic advance										
-ΔG	6.85	0.79	0.83	0.47	0.14	0.69	5.40	0.28	3.50	13.46
-ΔG%	14.74	16.64	16.48	14.74	49.18	13.66	4.93	21.24	11.87	28.96
Mini. number of genes										
-Castle-wright (1921)	0.39	1.18	1.86	0.10	0.10	0.24	0.24	0.22	2.90	1.06
-Mather &Jinks (1977)	0.76	2.61	3.50	0.16	0.10	0.40	0.50	0.46	6.57	2.00

**Table 1: Mean performance, variance, arithmetic mean and coefficient of variability for some important traits of sweet pepper in parents, F1, F2, Bc1 and Bc2 for the cross (B-10-24 x TS-6-3-3).**

Characters Populations	Plant height (cm)				No. of branches			
	X ± S.E	σ <sup>2</sup>	Arithmetic mean	C.V(%)	X ± S.E	σ <sup>2</sup>	Arithmetic mean	C.V(%)
P <sub>1</sub>	44.500±0.361	3.914	-	4.446	4.400±0.091	0.248	-	11.324
P <sub>2</sub>	56.467±0.433	5.637	-	4.205	7.300±0.098	0.286	-	7.329
F <sub>1</sub>	64.425±0.320	4.097	50.483 ns	3.142	6.725±0.071	0.204	5.850ns	6.724
F <sub>2</sub>	46.456±0.447	49.855	57.454ns	15.199	4.760±0.066	1.099	6.288ns	22.022
BC <sub>1</sub>	45.689±0.568	34.235	54.463ns	12.806	4.528±0.088	0.823	5.563ns	20.034
BC <sub>2</sub>	53.132±0.629	42.001	60.446ns	12.198	5.217±0.096	0.972	7.013ns	18.893
	Fruit length (cm)				Fruit diameter (cm)			
P <sub>1</sub>	5.880±0.100	0.297	-	9.271	4.504±0.069	0.142	-	8.354
P <sub>2</sub>	9.201±0.112	0.376	-	6.663	4.040±0.073	0.159	-	9.877
F <sub>1</sub>	8.295±0.075	0.223	7.541ns	5.687	3.271±0.051	0.106	4.272ns	9.940
F <sub>2</sub>	5.015±0.062	0.965	7.918ns	19.587	3.191±0.045	0.514	3.771ns	22.469
BC <sub>1</sub>	6.023±0.083	0.735	7.088ns	14.235	4.035±0.060	0.381	3.887ns	15.306
BC <sub>2</sub>	6.137±0.087	0.800	8.748ns	14.577	4.092±0.068	0.483	3.655ns	16.985
	Pericarp thickness (mm)				T.S.S %			
P <sub>1</sub>	0.184±0.004	0.001	-	12.257	5.037±0.060	0.109	-	6.543
P <sub>2</sub>	0.251±0.004	0.001	-	9.675	5.873±0.051	0.079	-	4.794
F <sub>1</sub>	0.265±0.005	0.001	0.218ns	11.217	5.818±0.041	0.066	5.455*	4.419
F <sub>2</sub>	0.285±0.007	0.011	0.241ns	36.676	5.051±0.041	0.428	5.636**	12.949
BC <sub>1</sub>	0.250±0.008	0.007	0.224ns	32.950	4.420±0.055	0.315	5.427**	12.697
BC <sub>2</sub>	0.234±0.009	0.008	0.258ns	38.002	5.731±0.055	0.321	5.845**	9.892
	Ascorbic acid content (mg/100g fresh weight)				Total yield/plant(kg)			
P <sub>1</sub>	113.100±0.448	6.024	-	2.170	0.998±0.042	0.052	-	22.831
P <sub>2</sub>	121.267±0.518	8.064	-	2.342	1.437±0.044	0.058	-	16.801
F <sub>1</sub>	119.675±0.353	4.994	117.183**	1.867	1.909±0.029	0.033	1.217**	9.563
F <sub>2</sub>	109.504±0.400	40.066	118.429**	5.780	1.334±0.024	0.144	1.563**	28.409
BC <sub>1</sub>	109.368±0.535	30.349	116.388**	5.037	1.092±0.029	0.091	1.453*	27.554
BC <sub>2</sub>	117.038±0.560	33.199	120.471**	4.923	1.710±0.037	0.145	1.673**	22.238
	Number of fruits/plant				Average fruit weight (g)			
P <sub>1</sub>	43.067±0.407	4.961	-	5.172	23.103±0.860	22.164	-	20.378
P <sub>2</sub>	22.733±0.398	4.754	-	9.591	62.939±1.145	39.314	-	9.962
F <sub>1</sub>	31.200±0.302	3.651	32.900**	6.124	61.350±1.32	42.593	43.021**	10.638
F <sub>2</sub>	29.468±0.293	21.471	32.050**	15.724	46.465±0.960	330.222	52.185**	32.655
BC <sub>1</sub>	31.642±0.412	18.004	37.133**	13.410	35.283±1.106	129.578	42.227**	32.263
BC <sub>2</sub>	26.736±0.401	17.072	26.967**	15.454	65.027±1.479	231.740	62.144**	23.410