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DIALLEL ANALYSIS FOR STUDYING HETEROSIS AND COMBINING ABILITY OF SOME ECONOMICAL YIELD TRAITS IN PUMPKIN

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ABSTRACT

This study was conducted in research farm and laboratories of Horticultural Research Institute, Agric. Res. Center during the period from 2012 to 2014 to estimate heterosis, and both general and specific combining abilities of some pumpkin (*Cucurbita maxima* Duch. ex Poir.) economical traits, *viz*., main stem length, number of branches/plant, number of nodes to first female flowers, average length, diameter and weight of fruit, average flesh thickness, number of fruits/plant, and total yield/plant. Five different inbred lines of pumpkin, namely *PK 27A* (P_1), *PK 27* (P_2), *PK 26* (P_3), *PK 33* (P_4), and *PK 31A* (P_5) were used for carrying out half diallel cross in all possible combinations excluding reciprocal. Results showed that the maximum significant true heterosis in desirable direction (71.8%) was recorded for TY followed by NB (67%), AFW (41.9%), NF (40.5%), MSL (39.5%), NNF (29.1%), AFL (28.7%) and AFD (12.4%). Analysis for combining ability indicated that general (GCA) and specific combining ability (SCA) variances were highly significant, indicating that both additive and non-additive gene effects involved in the expression of all studied traits except for NB and NF traits which were mainly controlled by non-additive and additive types of gene action, respectively. The ratios of GCA/SCA were higher than unity suggesting that the additive and additive by additive type of gene action was more important for most traits. Based on general combining ability effects, the parental lines $P_{3,}$ P_4 and P_5 were good combiners for most studied traits. The highest desirable SCA and heterotic effects were obtained from the crosses; ($P_1 \times P_4$), ($P_2 \times P_3$) and ($P_3 \times P_5$) for yield and most of the studied traits, which are the best and promising hybrids.
Keywords: *Pumpkin, Heterosis, GCA, SCA and Gene action*.

INTRODUCTION

Pumpkins, *Cucurbita maxima* Duch. ex Poir., are a member of the cucurbitaceae family. Pumpkins could be crossed with other plants of the same species, but not with cucumbers, watermelons or cantaloupes. Phenotypic diversity within populations of *Cucurbita* is high and includes variations in shape, size and colour of fruits, number and size of seeds, quality, colour and thickness of fruit flesh and precocity in fruit production (Hernandez *et al.,* 2005). The diallel analysis is a valuable method to evaluate parents and hybrid combinations. The presence of large amount of additive genetic variance would indicate that substantial progress could be achieved using selection in early segregating generations. On the other hand, the large amount of dominance and epistatic effects are necessary for heterosis and actually needed for the successful development of hybrids. Using F_1 hybrids is the quickest way of combining the valuable traits into one, besides the added advantages of heterotic yield (Choudhury *et al.,* 1965). The knowledge on gene action for expression of various quantitative traits is very essential in deciding the proper breeding method for genetic improvement. Different heterosis values for pumpkin were reported before by several authors. Heterosis over better parent was recorded for main stem length, number of primary branches, fruits/plant, average fruit weight, flesh thickness and yield (Mohanty and Mishra, 1999 a and b). Appreciable heterosis over better parent was found for fruits number/plant, fruit weight, flesh thickness and yield per plant (Sirohi *et al.,* 2002). Gajc-Wolska *et al.,* (2005) reported that yield of tested hybrids often higher than standard cultivars. Significant heterosis over better parent was appeared in order to magnitude by number of fruits (112.86%) followed by yield (65.44%), fruit weight (28.08%), fruit diameter (20.86%), fruit length (12.67%) and number of nodes to first female flower (-26.67%) as reported by Jha *et al.,* (2009). Pandey *et al.* (2010) estimated high heterosis to the extent of 36.36% to 60.00% for flesh thickness and -68.20% to 68.20% for yield trait. Jahan *et al.* (2012) found heterosis over better parent for nodes to first female flower, number of fruits per plant, average fruit weight and fruit yield. Also, significant hererosis over better parent was found in some evaluated hybrids for the traits; vine length, number of branches/plant, number of fruits/plant, average fruit weight, yield, flesh thickness, fruit length and fruit diameter (Gharib *et al.,* 2014).

Many studies on pumpkin breeding were focused on the analysis of combining ability and gene action to understanding the mode of inheritance of the economic traits such as Mohanty (2000), who found that mean squares for GCA and SCA were significant for the following traits; vine length, number of branches/plant, number of fruits/plant, flesh thickness, and yield. These suggesting the importance of both additive and non-additive genetic variance. Meanwhile, significant mean square due to SCA effect was found alone for average fruit weight indicating that this trait was exclusively governed by non-additive gene action. Also, Gwanama *et al.* (2001) reported that the effects of mean squares were significant for the mean fruit weight which indicating the presence of both additive and non-additive gene actions. Jha *et al.* (2009) found that GCA variances were higher than SCA variances for number of nodes to first female flower, number of fruits/plant and average fruit weight, indicating the limited scope of heterosis for these traits. While, GCA variances were lower than SCA variances for average fruit length, fruit diameter and yield which indicated that these traits may be improved through hybridization (heterosis) as indicating the predominance of non-additive gene action. Also, Pandey *et al.* (2010) found that GCA variance was higher than SCA variance for flesh thickness trait, while, yield per plant had lower GCA variance than SCA variance, which indicated the predominance of non-additive gene effect for yield and additive gene action for flesh thickness trait.

Most of the cultivated area of pumpkins in Egypt growing Balady cultivar. This cultivar is heterozygous for the fruit shape, size and color. Farmers have maintained local population of pumpkin and exchanged seeds with surrounding areas, mainly at local markets. It is a non-traditional vegetable often grown in small areas. This local population was adapted to diverse ecological conditions as a result of natural selection and also farmers selection. At the research level, the diversity of genetic resources in collections may increase the efficiency of efforts to improve species (Geleta *et al.,* 2005). Attention on development of F_1 hybrids in this crop is meager.

Hence, attempts have been made to study the magnitude of heterosis and the type of gene action controlling some economical traits in pumpkin using diallel crossing system. The objective of this investigation was to improve quantity and quality traits of pumpkin using heterosis and gene action.

MATERIALS AND METHODS

This study was conducted in research farm and laboratories of Horticulture Research Institute during the period from 2012 to 2014. Five different inbred lines of pumpkin namely; *PK 27A* (P_1), *PK 27* (P_2), *PK 26* (P_3), *PK 27A PK 33* (P_4), and *PK 31A* (P_5) were used as parental lines in the present investigation. These inbred lines were developed by Horticulture Research Institute, Agricultural Research Center, Egypt. Pumpkin seeds from many sources in Egypt were collected during the harvest time from open-pollinated populations grown by local farmers. Inbreeding was done for four times to insure high degree of purity of each parent before crossing. Thereafter, a half diallel cross among five parents was done to obtain ten F_1 hybrids in 2013. Fifteen genotypes including five parents and 10 F_1 hybrids were grown under open-field conditions in a randomized complete block design with three replications at Kaha Vegetable Research Farm, Kaliobia Governorate, during the summer season of 2014. Seeding dates were February 22nd, 2014. Each plot consisted of one row with ten meter length and 3 meter width, as well as, the plants were spaced with 75 cm. Each experimental plot area was 30 m^2 cultivated with ten plants. All agricultural practices were applied following the recommendations of Ministry of Agriculture, Egypt. Data were recorded on various evaluated genotypes with regard to some vegetative and yield traits. Main stem length (MSL) was measured at the harvesting time from the surface of the soil to the end of main stem in cm. Number of branches/plant (NB) was accounted as the number of branches from the soil to 50 cm length of main stem. Number of nodes to first female flower (NFF) was determined from cotyledons to first female flower on the main branch. Average fruit length (AFL) which measured in cm using average of 5 fruits by ruler. Average fruit diameter (AFD) was measured in cm using average of 5 fruits at the middle of the fruit by ruler. Average flesh thickness (AFT) which measured in cm as average weight of 5 fruits. Average fruit weight (AFW) was determined in kg as average weight of 5 fruits. Number of fruits/plant (NF) was determined as average of 5 plants. Total yield/plant (TY) which determined in kg by weighting all produced fruits/plant.

Heterosis (H%) was calculated according to Sinha and Khanna (1975) as the percentage of deviation from the better parent according to following formula:

$$\mathbf{H\%=} \frac{\mathbf{F_1 - BP}}{\mathbf{BP}} \mathbf{\times 100}$$

Where:

F_1 = Mean of the first filial generation.

BP = Mean of the better parent.

Data were statistically analyzed for the study of general (GCA) and specific (SCA) combining ability according to Griffing (1956) method II, model I.

RESULTS AND DISCUSSION

Mean performance and heterosis

Means and heterosis estimates over better parent are given in Table (1). Differences among genotypes (parents and hybrids) for all studied traits were significant. This indicated a wide diversity among the parental materials used in this study, which is essential for diallel cross design to be effective (Hayman 1954).

In general, F_1 crosses produced more desirable values than each of their corresponding parents for most studied traits.

The results appeared that main stem length (MSL) was ranged from 176.7 to 415.4 cm. considering both parents and hybrids. The cross $P_3 \times P_4$ revealed highest significant MSL (415.4 cm) for main stem length followed by the cross $P_2 \times P_3$ (354.6 cm) with a significant difference between them. Regarding to heterosis, two out of 10 evaluated hybrids exhibited significant positive heterosis over the taller parent. These crosses were $P_3 \times P_4$ (39.50%) and $P_2 \times P_3$ (25.17%). In addition, number of branches (NB) per plant ranged was from 1.83 to 3.82 for both parents and hybrids. The cross $P_1 \times P_4$ (3.82) had the highest NB followed by $P_1 \times P_3$ (3.70) showing in significant differences between them. Concerning heterosis, six out of ten evaluated hybrids exhibited significant positive heterosis over the higher parent for NB which ranging from 18.63% ($P_1 \times P_4$) to 67.00% ($P_3 \times P_5$).

Number of nodes to first flower (NNF) was ranged from 10.87 ($P_2 \times P_5$) to 20.67 (P_4). The cross $P_2 \times P_5$ (10.87) had the desirable negative NNF value, followed by $P_3 \times P_5$ (11.42) showing significant difference between them. Regarding to heterosis, seven hybrids exhibited significant desirable negative heterosis over its lower parent for this trait which ranged from 14.14 % ($P_1 \times P_{3,}$ latest cross) to -29.09% ($P_2 \times P_{5,}$ earliest cross).

Average fruit length (AFL) was ranged from 21.61 to 39.43 cm. The highest value (39.43 cm) of AFL was detected in fruits of the F_1 hybrid $P_2 \times P_4$ followed by the cross $P_1 \times P_4$ (39.26 cm) and $P_3 \times P_4$ (38.97 cm) recording insignificant differences between them. In respect to heterosis, six out of ten evaluated hybrids exhibited significant positive heterosis over its higher parent for AFL which ranged from 16.06% ($P_1 \times P_2$) to 28.70% ($P_2 \times P_3$).

Average fruit diameter (AFD) was ranged from 6.19 to 17.17 cm. The hybrid resulted from the cross $P_3 \times P_5$ (17.17 cm) and the parent P_3 (16.75 cm) had the higher significant value of AFD among all evaluated genotypes with insignificant differences between them. The lowest AFD was found in fruits of parents P_1 (6.19 cm) and P_2 (8.61 cm). Regarding to heterosis, two out of ten evaluated hybrids showed significant positive heterosis over its higher parent for AFD trait. These hybrids were resulted from crosses ; $P_4 \times P_5$ (14.00%) and $P_2 \times P_5$ (12.17%), where P_5 was a common parent in both.

Table 1. Mean performance (M) and heterosis based on better parent (H %) for some traits of 10 F_1's and their parents of pumpkin.

Genotype	Main stem length (cm)		Number of branches		Number of nodes to first flower		Average fruit length (cm)		Average fruit diameter (cm)	
	M	H%	M	H%	M	H%	M	H%	M	H%
PK 27A (P_1)	240.0		2.44		14.99		22.33		6.19	
PK 27 (P_2)	276.3		2.22		20.57		25.09		8.61	
PK 26 (P_3)	283.3		1.83		18.33		23.72		16.75	
PK 33 (P_4)	297.8		3.22		20.67		32.69		11.92	
PK 31A (P_5)	176.7		2.00		15.33		22.70		12.00	
Parental mean	254.8		2.34		17.98		25.31		11.10	
$P_1 \times P_2$	266.1	-3.69	1.83	-25.00**	17.11	14.14**	29.12	16.06*	9.32	8.25
$P_1 \times P_3$	341.8	20.65	3.70	51.64**	15.17	1.20	28.94	22.01**	12.82	-23.46**
$P_1 \times P_4$	354.0	18.87	3.82	18.63**	11.63	-22.41**	39.26	20.10**	11.75	-1.43
$P_1 \times P_5$	233.9	-2.54	3.61	47.95**	11.49	-23.35**	21.61	-4.80	13.49	12.42*
$P_2 \times P_3$	354.6	25.17*	3.56	60.36**	18.52	1.04	32.29	28.70**	14.69	-12.30**
$P_2 \times P_4$	333.6	12.02	3.53	9.63	16.30	-20.76**	39.43	20.62**	12.30	3.19
$P_2 \times P_5$	232.7	-15.78	3.33	50.00**	10.87	-29.09**	25.91	3.27	13.46	12.17*
$P_3 \times P_4$	415.4	39.50**	3.06	-4.97	15.50	-15.44**	38.97	19.21**	15.01	-10.39*
$P_3 \times P_5$	323.9	14.33	3.34	67.00**	11.42	-25.51**	23.79	0.30	17.17	2.51
$P_4 \times P_5$	244.4	-17.93	2.70	-16.15**	11.53	-24.79**	22.83	-30.16**	13.68	14.00*
F_1 mean	310.1		3.25		13.95		30.22		13.37	
LSD 0.05	59.00		0.36		0.39		3.85		1.37	
LSD 0.01	79.60		0.48		0.52		5.19		1.85	

Genotype	Average flesh thickness (cm)		Average fruit weight (kg)		No. fruits/plant		Total yield (kg/plant)	
	M	H%	M	H%	M	H%	M	H%
PK 27A (P_1)	1.13		0.35		2.22		0.71	
PK 27 (P_2)	1.60		0.70		1.92		0.97	
PK 26 (P_3)	3.15		2.60		1.33		2.48	
PK 33 (P_4)	1.78		2.07		1.67		3.84	
PK 31A (P_5)	2.57		1.83		1.93		3.40	
Parental mean	2.05		1.51		1.81		2.28	
$P_1 \times P_2$	1.63	1.88	0.96	37.14	2.63	18.47	1.50	54.64
$P_1 \times P_3$	2.23	-29.21**	2.24	-13.85	2.51	13.06	3.73	50.40
$P_1 \times P_4$	1.71	-3.93	2.10	1.45	3.12	40.54*	3.86	0.52
$P_1 \times P_5$	2.17	-15.56*	1.48	-19.13	2.67	20.27	2.43	-28.53
$P_2 \times P_3$	2.63	-16.51**	3.27	25.77*	2.07	7.81	4.26	71.77*
$P_2 \times P_4$	2.19	-21.22**	2.39	15.46	2.38	23.96	3.26	-15.10
$P_2 \times P_5$	2.07	-19.46*	2.15	17.49	1.89	-2.07	2.75	-19.12
$P_3 \times P_4$	2.34	-25.71**	3.69	41.92**	1.99	19.16	5.09	32.55
$P_3 \times P_5$	3.40	7.94	3.31	27.31*	2.43	25.91	5.10	50.00*
$P_4 \times P_5$	2.46	4.28	1.75	-15.46	1.83	-5.18	2.78	-27.60
F_1 mean	2.28		2.33		2.35		3.48	
L.S.D. 0.05%	0.38		0.56		0.85		1.46	
L.S.D. 0.01%	0.52		0.76		1.15		1.97	

*** &** indicate significance at 0.05 and 0.01 probability levels, respectively.**

Average fruit thickness (AFT) was ranged from 1.13 to 3.40 cm. The highest AFT was recorded by fruits of the hybrids resulted from the cross $P_3 \times P_5$ (3.40 cm), followed by the parent P_3 (3.15 cm) with insignificant differences between them. The lowest mean of AFT was given by the parent

P_1 (1.13 cm). Concerning heterosis, no crosses exhibited significant positive heterosis over their better parent for this trait.

Average fruit weight (AFW) was ranged from 0.35 to 3.69 kg. The highest AFW was recorded by fruits of the hybrids resulted from crosses; $P_3 \times P_4$ (3.69 kg), $P_3 \times P_5$ (3.31 kg) and $P_2 \times P_3$ (3.27 kg) with in significant differences among them. The lowest mean of AFW was given by the parents P_1 (0.35 g) and P_2 (0.70 g) without significant differences between them. Concerning heterosis, three out of ten evaluated hybrids exhibited significant positive heterosis over their better parent for AFW. These crosses are $P_3 \times P_4$ (41.92%), $P_3 \times P_5$ (27.31%) and $P_2 \times P_3$ (25.77%), where P_3 was a common parent.

Number of fruits/plant (NF) was ranged from 1.33 to 3.12. The hybrid resulted from the cross $P_1 \times P_4$ showed the highest significant NF (3.12) followed by the hybrids resulted from the crosses $P_1 \times P_5$ (2.67), $P_1 \times P_2$ (2.63) and $P_1 \times P_3$ (2.51) with insignificant differences between them, where P_1 was a common parent. Regarding to heterosis, only the hybrids resulted from the cross $P_1 \times P_4$ out of the 10 evaluated hybrids exhibited significant positive heterosis (40.54%) over its higher parent for NF.

Total yield per plant (TY) was ranged from 0.71 to 5.10 kg. The hybrid resulted from the cross $P_3 \times P_5$ produced the highest TY (5.10 kg) followed by the hybrids $P_3 \times P_4$ (5.09 kg), and $P_2 \times P_3$ (4.26 kg) which showed insignificant differences among them. Concerning heterosis, two out of ten evaluated hybrids showed significant positive heterosis over their better parent. These hybrids are $P_2 \times P_3$ (71.77%) and $P_3 \times P_5$ (50.00%), where P_3 was a common parent in both.

In general, some hybrids were taller and higher for AFD, AFW, NF and TY. Most crosses were earlier (lower NNF), higher NB and AFL than their better parents. However, no crosses were higher in AFT. This could be attributed to the significant superiority of parents over crosses. These results are partially in agreement with those of Mohanty and Mishra (1999a and b), Sirohi *et al.* (2002), Gajc-Wolska *et al.* (2005), Jha *et al.* (2009), Pandey *et al.* (2010), Jahan *et al.* (2012) and Gharib *et al.* (2014), who found significant heterosis over better parent for all studied traits.

Combining ability

Combining ability analysis (Table 2) showed highly significant mean squares due to both general and specific combining abilities for all studied traits. This revealed the important role of both additive and non-additive gene effects in the expression of all studied traits except for NB trait, which was mainly controlled by non-additive gene effects and NF trait which was affected by additive gene effect. However, the results showed that the variance due to GCA was larger in magnitude than that of SCA for all studied traits except NB. This means the greater role of additive and additive by additive types of gene effects in controlling these traits. In contrast, the trait NB had GCA/SCA ratio less than unity, revealing the predominance of non-additive gene effects in the inheritance of this trait. These results partially agreed with those of Mohanty (2000), who found that mean squares for GCA and SCA were significant for the traits; vine length, number of branches/plant, number of fruits/plant, flesh thickness and yield. Meanwhile, significant mean squares due to SCA effect was found only for average fruit weight. Similar results were obtained before by Gwanama *et al.* (2001), who found the presence of both additive and non-additive gene actions for the mean fruit weight trait. Also, Jha *et al.* (2009) found that GCA variances were higher than SCA variances for number of nodes to first female flower, number of fruits/plant and average fruit weight, while, the GCA variances were lower than the SCA variances for average fruit length, fruit diameter and yield. In addition, Pandey *et al.* (2010) stated the presence predominance of non-additive gene effects for yield and additive gene action for flesh thickness.

Table 2. Mean squares for general (GCA) and specific (SCA) combining ability for 10 F_1's and their parents.

Traits	GCA	SCA	GCA/SCA
Main stem length	8476.76**	2049.23**	4.14
Number of branches/plant	0.18	0.64**	0.28
Number of nodes to first flowers	17.47**	8.76**	1.99
Average fruit length	81.97**	26.41**	3.10
Average fruit diameter	24.06**	2.41**	9.98
Average flesh thickness	1.11**	0.06**	18.50
Average fruit weight	2.15**	0.40**	5.38
Number of fruits/plant	0.27*	0.18	1.50
Total yield/plant	3.37**	1.13**	2.98

Estimates of GCA effects for five parents are presented in Table (3). The GCA effects were significantly differed for most of the traits. Both parental genotypes P_3 and P_4 had positive GCA effects for MSL. This indicated that they were good combiners for this trait. Moreover, the two previously mentioned parents exhibited desirable GCA effects for average fruit weight and total yield/plant. The other parents such as P_5 were classified as a good combiner for number of nodes to first flower. This parent was also considered as a good combiner for at least one to three other traits. Although, the parental genotype P_1 appeared to be poor general combiner for AFW, however it was a good combiner for NNF and NF.

Table 3. Estimates of general combining ability effect (GCA) of parental genotypes.

Parents	MSL	NB	NNF	AFL	AFD	AFT	AFW	NF	TY
PK 27A (P_1)	-10.57	0.02	-0.91**	-1.127*	-2.27**	-0.46**	-0.6965**	0.33**	-0.79**
PK 27 (P_2)	-1.47	-0.14	1.74**	0.780	-1.24**	-0.22**	-0.3122**	-0.03	-0.68**
PK 26 (P_3)	36.08**	-0.05	0.79**	-0.007	2.50**	0.53**	0.7650**	-0.20*	0.67**
PK 33 (P_4)	27.59**	0.27**	0.65**	4.915**	0.13	-0.14**	0.2430**	-0.05	0.60**
PK 31A (P_5)	-51.64**	-0.10	-2.26**	-4.561**	0.88**	0.29**	0.0007	-0.05	0.20**
S.E. ($\hat{g}_i$-$\hat{g}_j$)	10.888	0.158	0.071	0.710	0.253	0.070	0.104	0.157	0.270

MSL= Main stem length, NB= Number of branches/plant, NNF= Number of nodes to first female flower, AFL= Average fruit length, AFD= Average fruit diameter, AFT= Average flesh thickness, AFW= Average fruit weight, NF= Number of fruits/plant and TY= Total yield/plant.

Respecting SCA, the data obtained in Table (4) indicated that F_1 hybrids resulted from the crosses; $P_1 \times P_4$, $P_3 \times P_4$ and $P_3 \times P_5$ achieved significant positive SCA effects for MSL. Seven crosses ($P_1 \times P_3$, $P_1 \times P_4$, P_1

× P_5, P_2 × P_3, P_2 × $P_{4,}$ P_2 × P_5 and P_3 × P_5) showed significant SCA effects for NB. While the crosses (P_1 × $P_{4,}$ P_1 × P_5, P_2 × P_4, P_2 × P_5, P_3 × P_4, P_3 × P_5 and P_4 × P_5) showed highly significant desirable SCA effect for NNF. Four crosses (P_1 × P_4, P_2 × P_3, P_2 × P_4 and P_3 × P_4) showed significant SCA effects for long fruit. However, only one hybrid (P_4 × P_5) exhibited significant SCA effects for short fruit. Six crosses (P_1 × P_4, P_1 × P_5, P_2 × $P_{3,}$ P_2 × $P_{4,}$ P_2 × P_5 and P_3 × P_5) had highly significant positive SCA effects for AFD. Two hybrids, *viz.,* P_2 × P_4 and P_3 × P_5 showed highly significant positive SCA effects for average flesh thickness. Significant positive SCA effects were observed in six crosses (P_1 × P_4, P_2 × P_3, P_2 × P_4, P_2 × P_5, P_3 × P_4 and P_3 × P_5) for heavy fruits. However, only the cross P_4 × P_5 gave significant negative SCA effect for fruit weight. Both crosses (P_1 × P_4) and (P_3 × P_5) showed significant SCA effect for NF. Respecting TY, the SCA effect for P_1× $P_{3,}$ P_1 × P_4, P_2 × P_3 and P_3 × P_5 was significantly positive, however the SCA effect for P_4 × P_5 was significantly negative.

As shown from the results presented in Table (4), the best hybrids were derived from the cross P_3 × $P_{5,}$ where P_3 was used as a female parent. This was already characterized by longest stem, moderate NNF and highest in both AFT and AFW, as well as, it was classified as a good combiner for yield and other four traits (MSL, AFD, AFT and AFW). In addition, the cross (P_3 × P_5) was derived from high × high general combiner parents for yield and exhibited highest mean yield, highest true heterosis and highest SCA effects for yield. It was also showed a desirable heterosis and highly significant SCA effects for at least four important traits (AFT, AFW, NF and TY). Therefore, cross combinations conducted for genetic improvement either for yield or some of its important components through selection in segregating generations were done to exploit a fixable additive gene action that related to significance GCA effect. It was also used for exploitation of non-additive gene effect which is due to the significance SCA effect in heterosis breeding.

Table 4. Estimates of specific combining ability effect (SCA) for F_1s of five pumpkin parents.

Crosses	MSL	NB	NNF	AFL	AFD	AFT	AFW	NF	TY
P_1× P_2	-13.47	-1.00**	0.993**	0.89	0.22	0.10	-0.09	0.16	-0.11
P_1× P_3	24.68	0.78**	-0.002	1.50	-0.02	-0.04	0.11	0.20	0.78*
P_1× P_4	45.34**	0.58**	-3.396**	6.89**	1.28**	0.11	0.49**	0.67**	0.97**
P_1× P_5	4.47	0.74**	-0.636**	-1.28	2.28**	0.14	0.12	0.21	-0.06
P_2× P_3	28.31	0.80**	0.704**	2.93*	0.82*	0.12	0.76**	0.13	1.19**
P_2× P_4	15.84	0.46*	-1.380**	5.16**	0.79*	0.34**	0.40**	0.29	0.26
P_2× P_5	-5.80	0.63**	-3.909**	1.11	1.21**	-0.21*	0.41**	-0.20	0.15
P_3× P_4	60.09**	-0.11	-1.228**	5.49**	-0.23	-0.25**	0.62**	0.07	0.75
P_3× P_5	47.86**	0.55*	-2.407**	-0.22	1.18**	0.39**	0.49**	0.50*	1.16**
P_4× P_5	-23.15	-0.41	-2.152**	-6.10**	0.06	0.11	-0.56**	-0.23	-1.20**
S.E.(S_{ij}-S_{ik})	37.720	0.547	0.247	2.459	0.876	0.244	0.359	0.543	0.934

MSL= Main stem length, NB= Number of branches/plant, NNF= Number of nodes to first female flower, AFL= Average fruit length, AFD= Average fruit diameter, AFT= Average flesh thickness, AFW= Average fruit weight, NF= Number of fruits/plant and TY= Total yield/plant.

In conclusion, it could be concluded that the parental lines P_3, P_4 and P_5 were good general combiners. In addition, the hybrids resulted from crosses $P_1 \times P_4$, $P_2 \times P_3$ and $P_3 \times P_5$ were the best and promising hybrids. The results also pointed at the potential of certain crosses as sources for selecting high yielding lines through their segregating generations. This was due to the additive gene effects which responsible for their good performance.

REFERENCES

Choudhury, B. ; R. S. Punia and H. S. Sangha (1965). Manifestation of hybrid vigour in F_2 generation of tomato (*Lycopersicon esculentum* Mill.). Indian J. Hort., 22: 52-59.

Gajc-Wolska, J.; M. Gajewski; J. Radzanowska; K. Niemirowicz-Szczytt and A. Korzeniewska (2005). The fruit quality assessment of the chosen hybrids and cultivars of pumpkin (*Cucurbita moshchata* Duch.). Vegetable Crops Research Bulletin, 63: 33-44.

Geleta, L. F.; M. T. Labuschagne and C. D. Viljoen (2005). Genetic variability in pepper (*Capsicum annuum* L.) estimated by morphological data and amplified fragment length polymorphism markers. Biodivers. Conserv., 14: 2361-2375.

Gharib, A. H. A.; A. M. Elgezawy; S. M. Elminiawy and M. M. Abdelsalam (2014). Utilization of heterosis in the development of some traits in pumpkin. Egypt. J. Appl. Sci., 29 (10): 482-493.

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

Gwanama, C.; A. M. Botha and M. T. Labuschagne (2001). Genetic effects and heterosis of flowering and fruit characteristics of tropical pumpkin. Plant Breed., 120: 271-272.

Hayman, B. I. (1954). The theory and analysis of diallel crosses. Genet. 39: 789-809.

Hernandez, S. M.; C. L. Merrick and L. Eguilarte (2005). Maintenance of squash (*Cucurbita* spp.) landrace diversity by farmers activities in Mexico. Genet. Resour. Crop Evol., 52: 697-707.

Jahan, T. A. ; A. K. M. A. Islam; M. G. Rasul; M. A. K. Mian and M. M. Haque (2012). Heterosis of qualitative and quantitative characters in sweet gourd (*Cucurbita moschata* Duch.ex Poir). Scholarly and Peer Reviewed. 12 (3): 6186-6199.

Jha, A; S. Pandey; M. Rai; D.S. Yadav and T.B. Singh (2009). Heterosis in relation to combining ability for flowering behaviors and yield parameters in pumpkin. Veg. Sci. 36 (3): 332-335.

Mohanty, B. K. (2000). Gene action for quantitative characters in pumpkin. Indian Agriculturist 44: 3/4, 157-163.

Mohanty, B. K. and R. S. Mishra (1999a). Studies on heterosis for yield and yield attributes in pumpkin (*Cucurbita moshchata* Duch ex. Poir). Indian J. Hort. 56 (2): 173-178.

Mohanty, B. K. and R. S. Mishra (1999b). Heterosis for yield and yield components in pumpkin (*Cucurbita moshchata* Duch Ex. poir). Indian J. Genet. 59 (4): 505-510.

Pandey S.; A. Jha; S. Kumar and M. Rai (2010). Genetics and heterosis of quality and yield of pumpkin. Indian J. Hort. 67 (3): 333-338.
Sinha, S. K. and R. Khanna (1975). Physiological, biochemical and genetic basis of heterosis. Adv. Agron. 27: 123-174.
Sirohi, P. S.; Y. S. Reddy and T. K. Behera (2002). Heterosis for yield and its attributing traits in pumpkin (*Cucurbita moschata* Duch. Ex poir). Veg. Sci. 29 (2): 178-179.

تحليل الهجن التبادلية لدراسة قوة الهجين والقدرة على الأئتلاف لبعض صفات المحصول الاقتصادية فى القرع العسلى

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أجريت هذه الدراسة بمزرعة معهد بحوث البساتين – مركز البحوث الزراعية – خلال الفترة من ٢٠١٢ إلى ٢٠١٤ و ذلك بهدف تقدير قوة الهجين وكلا من القدرة العامة والخاصة على التآلف لبعض الصفات الإقتصادية فى القرع العسلى وهى صفة طول الساق الرئيسى ، عدد الأفرع بالنبات ، عدد العقد حتى أول زهرة مؤنثة ، متوسط طول الثمرة ، متوسط قطر الثمرة ، متوسط سمك اللحم ، متوسط وزن الثمرة ، عدد الثمار بالنبات ، المحصول الكلى للنبات. إستخدمت فى الدراسة خمس سلالات مرباة تربية داخلية وهى *PK 27A* (P1) ، *PK 27* (P2) ، *PK 26* (P3) ، *PK 33* (P4) ، *PK 31A* (P5). أجرى التهجين بين هذه السلالات الأبوية بإتباع طريقة الهجن التبادلية بدون التلقيح العكسى. وقد أظهرت نتائج هذه الدراسة وجود قوة هجين فى بعض الهجن بالمقارنة بالأب الأفضل لصفات طول الساق الرئيسى ، متوسط سمك الثمرة ، متوسط وزن الثمرة ، عدد الثمار بالنبات ، والمحصول الكلى للنبات. ظهرت قوة الهجين فى معظم الهجن لصفات عدد الأفرع/النبات ، عدد العقد حتى أول زهرة مؤنثة ، متوسط طول الثمرة ، بينما لم تظهر قوة الهجين فى أى هجين بالنسبة لصفة متوسط سمك اللحم. تبين من النتائج وجود معنوية عالية لكل من تباين القدرة العامة والخاصة على التآلف لكل الصفات المدروسة مؤكدا أهمية كلا من الفعل المضيف وغير المضيف فى وراثة تلك الصفات ما عدا صفتى عدد الأفرع/النبات والتى يتحكم فيها الفعل غير المضيف فقط ، وكذلك صفة عدد الثمار بالنبات والتى يتحكم فيها الفعل المضيف فقط . أظهرت النسبة المحسوبة بين متوسط مربعات الانحرافات للقدرتين العامة والخاصة على التآلف أن الفعل المضيف للجينات كان يلعب دورا أكثر أهمية من الفعل غير المضيف فى وراثة جميع الصفات ما عدا صفة عدد الأفرع/النبات حيث لعب الفعل غير المضيف للجينات الدور الأكثر أهمية فى وراثة هذه الصفة. وقد أوضحت النتائج أن السلالات P_3 ، P_4 ، P_5 كانت متفوقة تفوقا إيجابيا فى القدرة العامة على التآلف لكثير من الصفات ، فى حين أثبتت القدرة الخاصة على التآلف تفوق الهجن الناتجة من التهجينات التالية $P_1 \times P_4$ ، $P_2 \times P_3$ ، $P_3 \times P_5$ فى معظم الصفات المدروسة وبذلك فهى تعتبر هجن واعدة.