Egypt. J. of Appl. Sci., 36 (5-6) 2021 *87-99*

INHERITANCE OF EARLINESS, YIELD AND ITS COMPONENTS IN GARDEN PEA (*PISUM SATIVUM* L.)

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Key Words: Pea, *Pisum sativum* L., combining ability, potence ratio and heterosis.

ABSTRACT

This study was carried out during the two winter seasons of 2019/2020 and 2020/2021 to study the type of gene action controlling some economic characters in garden pea *(Pisum sativum* L.) using six genotypes by hybridized in a half diallel model. Genotypes (parents and F_1 crosses) were grown in randomized complete block design with three replications to estimate general combining ability effects of the parents and specific combining ability effects of crosses, heterosis as deviation from mid and better parent and potence ratio for some economic characters, *viz.,* plant height, number of days to flowering, number of branches/plant, number of seeds/pod, number of pods/node, pod length, pod weight, 10- green seeds weight and shelling percentage. Results indicated that all studied traits showed significant mid parent and better parent heterosis in desirable direction in some crosses except the better parent heterosis for number of seeds/pod trait. Also, all studied traits exhibited different types of potence ratio.

INTRODUCTION

Legumes is the third upmost family of vegetable plants **(Lewis *et al*. 2005)**. Universally, pea (*Pisum sativum* L.) is the second most important legume crop after common bean **(Kumari *et al*. 2013)**. In Egypt, the total cultivated area grown with garden pea in 2015/2016 was 41819 feddans produced 183282 tons with an average of 4.383 tons/fed. **(Malr 2018)**. The major goal for pea breeding is developing high-yielding varieties with stable yields **(Abo-Hamda 2019)**. Hybridization is an effective factor for producing variability to induce new lines and developing quantitative traits in pea. Earliness and high yield potential became main requirements for accepting any new pea cultivar. The structure of gene effects is a pointer for evaluating selection value of the parental components and is used widely in breeding and applied genetic research. A diallel method of crossing based on the data of F_1 hybrids is an accurate method for its determination **(Srivastava *et al*. 2000, Bourion *et al.* 2002, Suman *et al*. 2017 and Manjunath *et al* 2020)**. It is determined as the general and specific combining abilities which were important for horticultural trait. Of a special importance is the choice of parents used in developing heterosis over the mid and better- parent and heterotic lines are very important in genetic analysis of quantitative traits.

Hamed (2005) and Hamed *et al*., (2015) found that positive heterosis over the better parent for plant length was ranged from 6.44% to 104.21%. **El-Dakkak (2016)** found negative heterosis (-16.82%) based on the tallest parent for this trait. Significant positive heterosis based on early parent was observed in all garden pea crosses for days to flowering trait **(Hamed 2005)**, while, **Noser (2002)** found negative heterosis in some crosses and positive heterosis values in the others. **Zayed *et al*., (2005)** reported that the maximum significant heterosis in desirable direction was recorded for number of seeds/pod. **Pandey *et al*., (2006)** found that average heterosis was observed for plant height, pods per plant, pod length and seeds per pod. **Hasan *et al*., (2010)** found that the maximum significant mid parent heterosis in desirable direction was recorded for stem length trait. **El-Dakkak and Hussein (2009)** confirmed the partial dominance for earliness and over dominance for the remainder growth trait stem length and number of branches. The inheritance of quantitative characters in peas has long been investigated. **Suman *et al*., (2017) and Manjunath *et al*., (2020)** observed that both general and specific combining abilities were important for hundred seed weight and number of seeds per pod. Also, **Al-Hamdany (2014) and Askander *et al*., (2018)** reported that general combining ability was significant for the traits plant height, 100 seeds weight and pod weight but non-significant for seeds pod, while SCA for most characters was significant in pea.

The aim of this research was studying the type of gene action controlling some economic characters in garden pea using six genotypes by hybridized in a half diallel model in order to study the genetics components of the traits.

MATERIALS AND METHODS

This study was carried out at Barrage Horticulture Research Station (BHRS), Kalubia Governorate, Agriculture Research Center (ARC), Egypt, during the two winter seasons of 2019/2020 and 2020/2021. Six diverse pea genotypes *(Pisum sativum* L.) represented a wide range of variability in their economic traits were chosen in this study as shown in Table 1. Seeds of these parents were planted on 3rd November 2019 to produce crosses by half diallel method among the six genotypes in all possible combinations and obtain 15 F_1 hybrids. In 20th October 2020 seeds of six parents and fifteen crosses (F_1's) were sown in the open field in a randomized complete block design with three replicates. The parents were represented by three rows, while the F_1 populations were represented by single row per block. Each row was 3 m long and 0.8 m wide. Individual seeds were sown 15 cm apart.

All cultural practices were applied according to the recommendations of the Egyptian Ministry of Agriculture.

Table 1. Genotypes of garden pea employed in the investigation.

Genotype	Parent	Source	Specific traits
M-g	**P_1**	**[Z]HRI, ARC, Egypt**	**Medium stem length, early, long green pods, big seed size**
Dakota	**P_2**	**Vermont Bean Seed Co.**	**Short stem length, very early, short green pods, small seed size**
Sienna	**P_3**	**Stokes Seeds Co.**	**Short stem length, late, dark green pods, small seed size**
M-62	**P_4**	**HRI, ARC, Egypt**	**Short stem length, early, long dark green pods, big seed size**
E-22	**P_5**	**HRI, ARC, Egypt**	**Long stem length, late, long dark green pods, plant vigor, medium seed size**
Ps 510571	**P_6**	**USA**	**Long stem length, very late, short light green pods, plant vigor, small seed size**

[Z] HRI: Hort. Res. Institute, Agric. Res. Center, Egypt (Hamed *et al*. 2017).

Data were registered for all populations (6 parents and 15 produced hybrids) for horticultural characters, *viz.*, plant height (cm), number of days to flowering, number of branches/plant, number of pods per node, pod length (cm), pod weight (g), number of seeds per pod, 10-green seeds weight (g) and shelling percentage (%). Statistical analysis was done using computer statistical software program Statistix, ver. 8. Analysis of variance for randomized complete block design was carried out according to **Snedecor and Cochran (1982).** Means for parents and F_1's generations were compared using Duncan's multiple range test (**Duncan 1955)**. Two types of heterosis [mid-parent heterosis (MPH) and better parent heterosis (BPH)] were estimated and expressed as percentages **(Sinha and Khanna 1975)**. The 't' test was manifested to determine whether F_1 hybrid means were statistically different from mid parent and better parent means as follows **(Wynne *et al*. 1970):** "t" for MPH= (F_1 -MP)/√3\8 (EMS). "t" for BPH= (F_1 -BP)/√1\2 (EMS). Where: F_1 = The mean of the F_1 cross, MP = The mid parent for the cross, BP = The better parent values for the cross and EMS = Error mean square. Potence ratio was calculated according to **Smith (1952)** to determine the degree of dominance as follows: P = (F_1 – MP)/0.5 (P_2 – P_1). Where P: relative potence of gene set, F_1: first generation mean, P_1: the mean of lower parent, P_2: the mean of higher parent and MP: mid-parents' value = (P_1 + P_2) \2. Complete dominance was indicated when P = ±1, while partial dominance was indicated when "P" is between (-1 and +1), except the value zero which indicates absence of dominance. Overdominance was considered when potence ratio exceeds ±1. The positive and negative signs indicate the direction of dominance of either parent. Griffing's method 2 model 1 using parents and F_1's without reciprocal (**Griffing 1956)** was used to estimate general combining ability (GCA) for the six parents and specific combining ability (SCA) for their fifteen hybrids as outlined by **Singh and Chaudhary (1985)**.

RESULT AND DISCUSSION

Mean performance.

The six parental lines and fifteen F_1 crosses differed significantly for each of the nine studied characters (Table 2). P_6 was the highest genotype in plant height trait, while P_2 genotype was the earliest one. P_6 genotype gave the highest number of branches/plant, meanwhile, P_2 and P_3 genotypes gave highest number of pods/node. P_5 gave the tallest pod, moreover, P_1 produced the heaviest pod weight. P_1 and P_4 gave the highest number of seeds/pod and the heaviest 10-green seeds weight, while P_1 gave the significant highest values of shelling percentage. These results agree with **Zayed *et al*., (2005); El-Dakkak and Hussein (2009) and Abd El-Atty *et al*., (2010)** who found variation for these traits among studied genotypes. Also, significant variations were obtained among all produced F_1 hybrids for all studied traits. Regarding plant height, the cross P_4 x P_6 was the highest one (141.23 cm) as compared with the other crosses, while, P_3 x P_5 was the shortest cross (50.50 cm). Meanwhile, P_1 x P_2 cross exhibited earliness in number of days to flowering (29 days) as compared with the other crosses. In addition, P_4 x P_6 cross had the highest number of branches/plant. The trait number of pods/node obtained significant differences among all studied crosses. P_3 x P_4 cross was the best cross for the traits pod length, pod weight and 10-green seeds weight. The crosses P_2 x P_4, P_3 x P_4, P_2 x P_5, P_1 x P_4 and P_1 x P_5 were the best for number of seeds/pod. P_2 x P_5 cross gave the highest shelling percentage. These results agreed with those obtained by **Zayed *et al*., (2005), El-Dakkak and Hussein (2009) and Abd El-Atty *et al*., (2010)** who indicate the present of variation among studied hybrids.

General and specific combining ability

The effect of general combining ability for parents was estimated in Table (3). The obtained data showed that P_1 was good combiner for the traits plant height, no. of pods/node, pod length, pod weight, no. of seeds/pod, 10-green seeds weight and shelling percentage, meanwhile, it had positive effect for number of days to flowering but was not significant. Also, P_2 was significantly good combiner in the desirable direction for the traits no. of days to flowering, no. of pods/pod, pod length, no. of seeds/pod, 10-green seeds weight and shelling percentage. Data indicated that the parent P_3 had significant GCA effect for the traits no. of pods/node, pod length, pod weight and shelling percentage. General combining ability for P_4 was significant towards the desirable direction for all traits except the traits no. of days to flowering and no. of pods/node. It was noticed that the genotype P_5 was significantly good combiner for the traits no. of days to flowering, pod length and no. of seeds/pod. For the genotype P_6, data indicated that it had significant GCA effect only for the traits plant height and no. of branches/plant.

Table 2. Average performance of studied six parents and their fifteen hybrids of pea during 2020/2021.

Genotypes	Plant height (cm)	Number of days to flowering	No. of branches /plant	No. of pods/node	Pod length (cm)	Pod weight (g)	No. of seeds/pod	10- green seeds weight (g)	shelling percentage (%)
Parents									
M-g (P1)	76.20 c	33.00 e	2.37 d	1.33 ab	9.63 c	6.75 a	7.32 d	4.53 a	49.32 c
Dakota (P2)	56.67 f	27.00 f	2.33 d	2.00 a	8.67 d	4.20 d	8.49 c	2.90 b	58.66 b
Sienna (P3)	61.83 e	45.00 b	3.03 c	2.00 a	9.50 c	3.91e	6.12 e	2.90 b	46.96 d
M-62 (P4)	68.00 d	35.00 d	2.60 cd	1.00 b	10.90 b	6.28 b	9.17 b	4.50 a	71.95 a
E-2 (P5)	100.40 b	41.00 c	4.00 b	1.00 b	13.60 a	5.57 c	10.19 a	3.12 b	45.58 e
Ps 510571 (P6)	234.13 a	74.00 a	4.67 a	1.67 ab	5.17 e	1.89 f	3.87 f	1.77 c	36.53 f
Crosses									
$P_1 \times P_2$	87.17 f	29.00 j	2.00d	2.00 a	8.50 e	3.36 hi	5.13 e	3.36 de	45.04 fg
$P_1 \times P_3$	81.25 g	39.997 f	2.00 d	2.00 a	9.97 cd	5.06 e	7.62 d	3.15 f	47.96 e
$P_1 \times P_4$	79.00 h	39.997 f	2.00 d	1.50 ab	10.50 bc	7.14 b	9.25 ab	3.96 bc	35.97 j
$P_1 \times P_5$	68.86 j	39.00 fg	2.00 d	1.67 a	10.77 b	5.90 d	9.20 ab	3.96 bc	44.38 g
$P_1 \times P_6$	111.67 d	50.00 e	4.53 b	1.00 b	6.63 g	2.62 j	5.23 e	2.09 hi	45.76 f
$P_2 \times P_3$	55.50 l	34.00 i	3.17 c	2.00 a	7.77 f	4.13 g	7.00 d	3.20 ef	52.58 c
$P_2 \times P_4$	64.67 k	34.00 i	2.00 d	1.00 b	10.41 bc	6.39 c	9.43 a	4.06 b	52.72 c
$P_2 \times P_5$	71.67 i	37.00 h	3.00 cd	2.00 a	9.53 d	4.37 f	9.00 ab	3.43d	65.69 a
$P_2 \times P_6$	131.73 b	59.00 c	2.67 cd	2.00 a	6.467 g	3.27 i	5.00 e	2.73 g	52.72 c
$P_3 \times P_4$	56.17 l	40.00 f	2.00 d	1.00 b	11.43 a	8.70 a	9.13 ab	5.11 a	39.977 i
$P_3 \times P_5$	50.50 m	38.00 gh	3.00 cd	1.00 b	10.73 b	4.20 fg	8.53 bc	2.29 h	47.62 e
$P_3 \times P_6$	125.67 c	65.00 a	2.00 d	2.00 a	5.77 h	1.61 l	3.00 f	1.90 i	45.15 fg
$P_4 \times P_5$	90.50 e	38.00 gh	2.00 d	2.00 a	10.44 bc	5.08 e	7.75 cd	3.77 c	42.88 h
$P_4 \times P_6$	141.23 a	54.00 d	7.00 a	1.00 b	6.17 gh	3.53 h	5.67 e	3.90 bc	57.62 b
$P_5 \times P_6$	130.67 b	62.00 b	3.00 cd	2.00 a	5.73 h	1.896 k	3.00 f	2.70 g	49.53 d

Values having the same alphabetical letter(s) in common within each column don't significantly differ using the revised L.S.D. test at 0.05 level of probability

Table 3. Estimation of general and specific combining ability effects of parents and hybrids for studied characters in pea.

Genotypes	Plant height	No. of days to flowering	No. of branches/ plant	No. of pods/node	Pod length	Pod weight	No. of seed/pod	10- green seeds weight	shelling percentage
GCA									
Master Gaara (P1)	2.45**	0.08	-0.15*	0.14**	0.84**	0.86**	0.42**	0.53**	0.74*
Dacota (P2)	-4.58**	-2.04**	-0.12*	0.41**	0.13**	-0.10*	0.60**	0.16*	9.28**
Sin (P3)	-8.50**	5.46**	-0.03	0.28**	0.72**	0.10*	-0.02	0.02	1.92**
Master 62 (P4)	0.86*	1.58**	0.22**	-0.15**	1.48**	1.59**	1.48**	1.06**	7.65**
Entesar 22 (P5)	-26.13**	-11.42**	-0.43**	-0.38**	0.50**	-0.24**	0.52**	-0.54**	-8.71**
225 (P6)	35.90**	6.33**	0.51**	-0.30**	-3.66**	-2.22**	-3.01**	-1.23**	-10.88**
gi-gj	0.18	0.10	0.09	0.07	0.05	0.02	0.08	0.03	0.10
SCA									
$P_1 \times P_2$	9.19**	-6.66*	-0.37	0.06	-0.89*	-1.79**	-2.71**	-0.37**	-9.53**
$P_1 \times P_3$	7.19**	-3.16*	-0.46	0.19	-0.01	-0.29*	0.40**	-0.45**	0.75*
$P_1 \times P_4$	-4.41**	0.71	-0.71	0.13	-0.23	0.31**	0.53**	-0.68**	-16.96**
$P_1 \times P_5$	12.43**	12.72**	-0.06	0.52*	1.01**	0.89**	1.44**	0.92**	7.80**
$P_1 \times P_6$	-6.79**	5.96**	1.54**	-0.23	1.04**	-0.41**	1.01**	-0.26**	11.35**
$P_2 \times P_3$	-11.53**	-7.03**	0.68	-0.08	-1.50**	-0.26*	-0.40**	-0.02	-3.16**
$P_2 \times P_4$	-11.71**	-3.16*	-0.74	-0.65*	0.38	0.52**	0.53**	-0.20**	-8.77**
$P_2 \times P_5$	22.28**	12.84**	0.91*	0.58*	0.48	0.32**	1.06**	0.77**	20.57**
$P_2 \times P_6$	20.31**	17.09**	-0.36	0.50*	1.58**	1.20**	0.59**	0.76**	9.77**
$P_3 \times P_4$	-16.30**	-4.66*	-0.83*	-0.52*	0.82*	2.62**	0.86**	0.99**	-14.14**
$P_3 \times P_5$	-21.96**	-6.66*	0.17	-0.52	0.12	-1.88**	0.26**	-1.84**	-6.51**
$P_3 \times P_6$	18.16**	15.59**	-1.12*	0.63	0.29	-0.66**	-0.78**	0.07	9.56**
$P_4 \times P_5$	35.67**	10.21**	-0.42	1.15**	0.05	-0.66**	-1.07**	0.21*	-0.62*
$P_4 \times P_6$	24.38**	8.46**	3.64**	0.06	-0.07	-0.22**	0.38**	1.02**	16.30**
$P_5 \times P_6$	-220.53**	-94.54**	-5.71**	-2.71**	-10.99**	-3.82**	-7.33**	-3.97**	-74.49**
sij-skl	0.44	0.24	0.21	0.16	0.12	0.05	0.18	0.07	0.26

Concerning the SCA of studied crosses (Table 3), data showed that the earliest crosses due to SCA effects were $P_1 \times P_2$, $P_1 \times P_3$, $P_2 \times P_3$, $P_2 \times P_4$, $P_3 \times P_4$, $P_3 \times P_5$ and $P_5 \times P_6$. The shortest crosses were $P_1 \times P_4$, $P_1 \times P_6$, $P_2 \times P_3$, $P_2 \times P_4$, $P_3 \times P_4$, $P_3 \times P_5$ and $P_5 \times P_6$. The valuable positive SCA effects were detected in the crosses $P_1 \times P_6$, $P_2 \times P_5$ and $P_4 \times P_6$ for the trait no. of branches/plant, while, the valuable negative SCA effects were detected in the hybrids $P_3 \times P_4$, $P_3 \times P_6$ and $P_5 \times P_6$. Specific combining ability recorded effect in desirable direction for the trait no. of pods/node in the crosses $P_1 \times P_5$, $P_2 \times P_5$, $P_2 \times P_6$ and $P_4 \times P_5$. The trait pod length showed positive significant SCA effect in the crosses $P_1 \times P_5$, $P_1 \times P_6$, $P_2 \times P_6$ and $P_3 \times P_{4,}$ however, the crosses $P_1 \times P_2$, $P_3 \times P_3$ and $P_5 \times P_6$ had negative significant effect. Six out of the 15 hybrids had positive significant SCA for pod weight, while, 9 out of 15 had negative significant SCA effect. Positive significant SCA effect in desirable direction was observed for the trait no. seeds/pod in all crosses except $P_1 \times P_2$, $P_2 \times P_3$, $P_3 \times P_6$, $P_4 \times P_5$ and $P_5 \times P_6$. While, SCA effect was detected in desirable direction for the trait 10 seeds weight in the crosses $P_1 \times P_5$, $P_2 \times P_5$, $P_2 \times P_6$, $P_3 \times P_4$, $P_4 \times P_5$ and $P_4 \times P_6$. Significant positive SCA effect for the trait shelling percentage was estimated in the crosses $P_1 \times P_3$, $P_1 \times P_5$, $P_1 \times P_6$, $P_2 \times P_5$, $P_2 \times P_6$, $P_3 \times P_6$ and $P_4 \times P_6$. These results are in line with the finding of **Askander *et al*., (2018).**

Heterosis

Heterosis over mid-parent for all studied traits are presented in Table (4). Results revealed that heterosis for the trait plant height varied from -37.74% to 31.21% and only 4 out of 15 crosses exhibited significant positive heterosis values over mid-parent. Heterosis for number of days to flowering varied from -11.63 to 17.64 % over mid-parent, meanwhile, 3 crosses out of 15 crosses exhibited significant negative heterosis ($P_1 \times P_6$, $P_2 \times P_3$ and $P_4 \times P_5$). With regard to trait no. of branches/plant, mid-parent heterosis varied from -48.05 to 92.57 %, moreover, 3 crosses ($P_1 \times P_6$, $P_2 \times P_3$ and $P_4 \times P_6$) out of 15 exhibited significant positive heterosis. Concerning number of pods/node, 8 crosses out of 15 exhibited significant and highly significant positive heterosis over mid-parent. Two crosses ($P_2 \times P_4$ and $P_3 \times P_4$) exhibited significant positive heterosis values over mid-parents in the trait pod length. Heterosis over mid-parents for the traits epod weight and number of seeds/pod varied from -49.15% to 70.76% and -57.33% to 19.42 %, respectively, meanwhile, the same 4 crosses ($P_1 \times P_3$, $P_1 \times P_4$, $P_2 \times P_4$ and $P_3 \times P_4$) gave significant positive heterosis. For 10- green seeds weight trait, heterosis over mid-parents varied from -33.65 to 38.11 % and the results showed that 8 crosses exhibited significant positive heterosis. Concerning shelling percentage trait, mid-parents heterosis ranged from -40.66 to 62.04 %, meanwhile, 6 crosses out of studied 15 exhibited significant positive heterosis. similar results have been reported by **Hasan *et al*., (2010), Brar *et***

***al*., (2012) and Galal *et al*., (2019)** who found positive heterosis in some studied crosses for horticultural traits of pea.

Table 4. Heterosis percentages (relative to the mid-parental value) of F_1 hybrids for some traits in pea.

Crosses	Plant height	No. of days to flowering	No. of branches / plant	No. of pods/node	Pod length	Pod weight	No. of seeds/pod	10- green seeds weight	shelling percentage
$P_1 \times P_2$	31.21**	-3.33	-14.89**	20.00**	-7.10*	-38.63**	-35.10**	-9.56*	-16.58**
$P_1 \times P_3$	17.73**	2.56	-25.93**	20.00**	4.23	-5.066	13.39**	-15.21**	-0.37
$P_1 \times P_4$	9.57**	17.64**	-19.52**	28.57**	2.29	9.59*	12.19*	-12.29**	-40.66**
$P_1 \times P_5$	-22.02**	5.41*	-37.21**	43.14**	-7.28*	-4.22	5.08	3.66	-6.47*
$P_1 \times P_6$	-28.03**	-6.54*	28.69**	-33.33**	-10.41**	-39.35**	-6.52*	-33.65**	6.60*
$P_2 \times P_3$	-6.33*	-5.56*	18.28**	0.00	-14.47**	1.85	-4.18	10.34*	-0.44
$P_2 \times P_4$	3.75	9.68*	-18.86**	-33.33**	6.39*	21.95**	6.795*	9.73*	-19.29**
$P_2 \times P_5$	-8.74*	8.82*	-5.21*	33.33**	-14.41**	-10.54*	-3.64	14.14**	26.04**
$P_2 \times P_6$	-9.40*	16.83**	-23.71**	9.09*	-6.50*	7.39*	-19.09**	16.92**	10.77*
$P_3 \times P_4$	-13.47**	0.00	-28.95**	-33.33**	12.06**	70.76**	19.42**	38.11**	-32.76**
$P_3 \times P_5$	-37.74**	-11.63**	-14.65**	-33.33**	-7.099*	-11.39*	4.598	-23.79**	2.92
$P_3 \times P_6$	-15.08**	9.24	-48.05**	9.09*	-21.34**	-44.48**	-39.94**	-18.63**	8.16*
$P_4 \times P_5$	7.48*	0.00	-39.39**	100.00	-14.78**	-14.26**	-19.94**	-0.92	-27.03**
$P_4 \times P_6$	-6.51*	-0.92	92.57**	-25.00**	-23.21**	-13.59**	-13.04**	24.40**	6.23*
$P_5 \times P_6$	-21.88**	7.83*	-30.80**	50.00**	-38.95**	-49.15**	-57.33**	10.66*	20.64**

Heterosis over better parent for studied traits are given in Table (5). Two out of the 15 studied hybrids exhibited significant positive better parent heterosis for the trait plant height (14.40% and 6.63% for the hybrids $P_1 \times P_2$ and $P_1 \times P_3$, respectively). With respect to number of days to flowering trait, all evaluated hybrids exhibited positive heterosis ranged from 7.41% to 118.52% except the hybrid $P_3 \times P_5$ which gave negative heteroses estimated as -7.32%. In the case of number of branches/plant trait, only the hybrid $P_4 \times P_6$ gave a significant positive better parent heterosis. Hybrids $P_1 \times P_4$, $P_1 \times P_5$, $P_4 \times P_5$ and $P_5 \times P_6$ showed significant heterosis (12.78%, 25.56%, 100.00% and 19.76%, respectively) in desirable direction for number of pods/node trait. For the traits pod length and number of seeds/pod, none of the evaluated crosses showed significant positive heterobeltiosis values. With regard to pod weight, only one cross ($P_3 \times P_4$) gave significant positive heterosis estimated as 38.54%. Three out of 15 evaluated crosses ($P_2 \times P_3$, $P_2 \times P_5$ and $P_3 \times P_4$) showed significant positive heterosis based on better parent for the trait 10-green seeds weight. For shelling percentage trait, only one hybrid ($P_2 \times P_5$) shows significant better parent heterosis in desirable direction estimated as 11.98%. These results agree with those found by **Al-Hamdany (2014), Hamed *et* al., (2015), Khalil *et al*., (2015), Askander *et al*., (2018), Abo-Hamda (2019) and Galal *et al*., (2019)** who estimated heterobeltiosis in some studied crosses for horticultural traits**.**

Table 5. Heterosis percentages (relative to the better-parental value) of F_1 hybrids for some traits in pea.

Crosses	Plant height	No. days to flowering	No. of branches / plant	No. of pods/node	Pod length	Pod weight	No. of seeds/pod	10-green seeds weight	shelling percentage
$P_1 \times P_2$	14.40**	7.41	-15.61**	0.00	-11.73*	-50.22**	-39.58**	-25.83**	-23.22**
$P_1 \times P_3$	6.63*	21.20**	-33.99**	0.00	3.53	-25.04**	4.10	-30.46**	-2.76
$P_1 \times P_4$	3.67	21.20**	-23.08**	12.78**	-3.67	5.78	0.87	-12.58*	-49.99**
$P_1 \times P_5$	-31.41**	18.18**	-50.00**	25.56**	-20.81**	-12.59**	-9.72	-12.58*	-10.02*
$P_1 \times P_6$	-52.30**	51.52**	-3.00	-40.12**	-31.15**	-61.19**	-28.55**	-53.86**	-7.22
$P_2 \times P_3$	-10.24*	25.93**	4.62	0.00	-18.21**	-1.67	-17.55**	10.34*	-10.36*
$P_2 \times P_4$	-4.90	25.93**	-23.08**	-50.00**	-4.495	1.75	2.84	-9.78	-26.74**
$P_2 \times P_5$	-28.62*	37.04**	-25.00**	0.00	-29.93**	-21.54**	-11.68*	10.29*	11.98*
$P_2 \times P_6$	-43.74**	118.52**	-42.83**	0.00	-25.37**	-22.14	-41.11**	-5.86	-10.13*
$P_3 \times P_4$	-17.40**	14.29*	-33.99**	-50.00**	4.86	38.54**	-0.44	13.56**	-44.43**
$P_3 \times P_5$	-49.70**	-7.32	-25.00**	-50.00**	-21.10**	-24.59**	-16.29**	-26.37**	1.41
$P_3 \times P_6$	-46.33**	44.44**	-57.17**	0.00	-39.26**	-58.82**	-50.98**	-34.48**	-3.85
$P_4 \times P_5$	-9.86*	8.57	-50.00**	100.00**	-23.24**	-19.11**	-23.95**	-16.22**	-40.40**
$P_4 \times P_6$	-39.68**	54.29**	49.89**	-40.12**	-43.39**	-43.79**	-38.17**	-13.33**	-19.92**
$P_5 \times P_6$	-44.19**	51.22**	-35.76**	19.76**	-47.43**	-65.95**	-70.56**	-13.18**	8.67

Potence ratio

Data of potence ratio (Table 6) indicated that the most F_1 crosses had negative nature for the trait plant height. The potence ratio estimates indicated over dominance towards the short parent, since their values were found more than one (P>1) in 7 evaluated crosses (most of them include the parents P_1 or P_3), meanwhile, partial dominance towards the short parent were found in 4 crosses. On the other hand, 2 hybrids had positive values of potence ratio, indicating partial towards the tall parent. However, one cross exhibited absence dominance. Different types of dominance were observed for number of days to flowering character. Negative P values were estimated indicating partial dominance towards the early parent in 2 studied crosses (P_1X P_6 and P_2X P_3). Five crosses exhibited absence dominance. However, Positive P values were estimated indicating overdominance, complete dominance and partial dominance towards the late parent in 8 crosses.

The results in Table 6 indicated that the potence ratio for 5 produced hybrids indicated complete and over dominance towards the high parent for number of branches/plant trait. On the other hand, 9 hybrids exhibited complete and over dominance towards the lowest parent. Meanwhile, one cross exhibited absence dominance. For number of pods/node, positive P values were estimated indicating overdominance and complete dominance towards high parent in 6 crosses, however, negative P values were observed indicating overdominance and complete dominance towards the low parent in 7 crosses, meanwhile, the crosses $P_2 \times P_3$ and $P_4 \times P_5$ exhibited absence dominance.

Table 6. Potence ratios of F_1 hybrids for some traits in pea.

Crosses	Plant height	No. of days to flowering	No. of branches/ Plant	No. of pods/node	Pod length	Pod weight	No. of seeds/pod	10-green seeds weight	shelling percentage
$P_1 \times P_2$	-2.12	0.33	17.50	1.00	1.35	1.66	-4.7	0.44	-1.92
$P_1 \times P_3$	-1.70	0.17	-2.12	1.00	-6.23	0.19	-1.5	0.69	0.15
$P_1 \times P_4$	-1.68	6.00	-4.22	-2.00	0.37	-2.66	1.09	37.0	-2.18
$P_1 \times P_5$	-1.61	0.50	-1.45	-3.02	-0.43	0.44	0.31	-0.197	1.64
$P_1 \times P_6$	-0.55	-0.17	0.88	-3.00	0.35	0.699	0.21	0.77	-0.44
$P_2 \times P_3$	-1.45	-0.22	1.40	0.00	-3.19	-0.52	0.26	0.00	0.04
$P_2 \times P_4$	0.41	0.75	-3.44	1.00	0.56	1.11	1.76	0.45	-1.895
$P_2 \times P_5$	-0.31	0.43	-0.20	-1.00	-0.65	-0.75	-0.4	4.05	-2.07
$P_2 \times P_6$	-0.15	0.36	-0.71	-1.00	0.26	-0.19	0.51	-0.699	-0.46
$P_3 \times P_4$	-2.83	0.00	3.79	1.00	1.76	3.04	0.97	1.76	-1.56
$P_3 \times P_5$	-1.59	2.50	-1.06	1.00	-0.4	-0.65	0.18	-6.81	-1.96
$P_3 \times P_6$	-0.26	0.38	-2.26	-1.00	0.72	1.28	1.77	0.77	-0.65
$P_4 \times P_5$	0.39	0.00	-1.86	0.00	-1.34	2.38	-3.78	0.05	1.20
$P_4 \times P_6$	-0.12	-0.03	3.25	-1.00	0.65	0.25	0.32	-0.56	-0.19
$P_5 \times P_6$	-0.55	0.27	-3.99	2.00	0.87	0.996	1.28	-0.39	-1.87

The results for pod length trait indicated that the potence ratio in 7 produced hybrids were positive indicating partial dominance or over dominance for this character towards the high parent, however, 6 of crosses were negative indicating partial, complete and over dominance towards the low parent. Two hybrids gave absence dominance. Different types of dominance were observed for pod weight trait. Negative P values were estimated indicating partial, complete and over dominance towards the lowest parent in 3 crosses. However, positive P values were estimated indicating partial, complete and over dominance towards the heaviest pod in 10 crosses. Two crosses exhibited absence dominance.

Positive P values were estimated for number of seeds/pod character indicating over dominance, complete dominance and partial dominance towards high parent in 6 crosses, however, over dominance towards low parent were found in 3 crosses, meanwhile, 6 crosses exhibited absence dominance. The results for 10 seeds weight trait indicated that the potence ratio in 8 studied hybrids were positive indicating partial dominance or over dominance for this character towards the high parent, however, 3 of crosses were negative indicating partial dominance towards the low parent, meanwhile, 4 hybrids gave absence dominance. With regard to shelling percentage trait, positive P values were estimated indicating over dominance towards high parent in 2 crosses, however, over dominance or partial dominance or towards low parent were found in 11 crosses, meanwhile, 2 crosses exhibited absence dominance.

These results partially agree with the observations of **El-Dakkak and Hussein (2009), Hamed *et* al., (2015), Khalil *et al*., (2015), Abo-Hamda (2019) and Galal *et al*., (2019)** in pea.

ACKNOWLEDGEMENT

The author is grateful to **Professor Dr. Ashraf Abdalla Hamed**, chief Researcher at Vegetables, Medicinal and Aromatic Plant Breeding Dep., Hort. Res. Inst., Agric. Res. Center, for encouragement, helping, supporting and cooperation.

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وراثة التبكير والمحصول ومكوناته في البسله

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مركز البحوث الزراعيه – معهد بحوث البساتين – قسم بحوث تربية الخضر والنباتات الطبية والعطرية

أجريت هذه الدراسة خلال الموسمين الشتويين 2020/2019 ، 2021/2020 و ذلك بهدف دراسة الفعل الجينى المتحكم فى بعض الصفات الاقتصادية في البسلة الخضراء باستخدام ستة طرز وراثية كأباء تم التهجين فيما بينهم باستخدام طريقة الهجن النصف دائرية. تم زراعة الطرز الوراثية (6 أباء + 15 هجين) بنظام القطاعات كاملة العشوائية في ثلاث مكررات لتقدير القدرة العامة والخاصة على التآلف ، وقوة الهجين مقارنة بكلأ من متوسط الأبوين وكذلك الأب الأفضل ، ودرجة السيادة لبعض الصفات الاقتصادية مثل ارتفاع النبات ، عدد الأيام حتى التزهير ، وعدد الأفرع بالنبات ، وعدد البذور بالقرن ، وعدد القرون بالعقدة ، طول القرن ، ووزن القرن ، ووزن 10 بذور ، ونسبة التصافي. وقد أكدت النتائج وجود قوة هجين فى الاتجاه المرغوب فى بعض الهجن وذلك مقارنة بكلأ من متوسط الأبوين وكذلك الأب الأفضل فى كل الصفات المدروسة ماعدا صفة عدد البذور بالقرن. كما أظهرت النتائج وجود طرز مختلفة من السيادة فى كل الصفات المدروسة .