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GENETIC STUDIES FOR IMPROVING PRODUCTIVITY OF PEA (*PISUM SATIVUM L.*)

BY

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ABSTRACT

Genetic behaviour of plant height, number of days to flowering, number of pods per plant, dry pod weight, number of seeds per pod, dry seeds weight per pod, average seed weight and dry seed yield per plant were studied in crosses between five cultivars of pea (*Pisum sativum* L.) and their reciprocals during years of 2000 to 2002 at Sids Horticulture Research Station, Beni-sueif Governorate, Egypt. The crosses used were Master B x Pss10699, Lincoln x Pss10699, Victory Freezer x Pss10699, Master B x Bountiful, Lincoln x Bountiful and Victory Freezer x Bountiful and their reciprocals.

Additive and non-additive effect played the important role in inheritance of all the previous characters. Over dominance was detected for earlienss of flowering, high number of pods per plant, high average seed weight and high dry seed yield per plant in some or most crosses. Meanwhile partial dominance was detected for the tall plants, high dry pod weight and high dry seeds weight per pod, and for the small number of seeds per pod in most crosses.

Broad-sense heritability was high for plant height and number of seeds per pod in the cross Master B x Pss10669. Moreover, broad-sense heritability was higher also for number of days to flowering in all crosses except in the cross Master B x Bountiful, number of pods per plant in the cross Master B x Bountiful, dry pod weight in all crosses except in the crosses Master B x Bountiful and Lincoln x Bountiful and dry seed yield per plant in the crosses Master B x Pss10699, Master B x Bountiful and Victory Freezer x Bountiful. Generally, the high estimates of broad-sense heritability for most studied traits indicated that selection can be used for improving of these characters in peas.

Generally, the genetical analysis demonstrated that a considerable amount of readily fixable variation is present and available for the plant breeder to manipulate.

INTRODUCTION

Garden pea (*Pisum sativum* L.) is one of most important legume crops in Egypt for local marketing. Growth characters such as plant height and number of days to flowering are considered the most important components for higher yield in pea. Moreover high pod quality is the major objective of pea breeding. Mihailovic *et al.* (1991); Anil *et al.* (1995) and Narayan *et al.* (1999) reported that number of pods per plant, dry pod weight, number of seeds per pod, dry seeds weight per pod and average seed weight are the main components of seed yield.

Additive and non-additive gene effects were predominant and important in the expression of plant height (Sharma *et al.*, 1999 and Sharma and Rastogi, 2001), number of days to flowering (Parmar and Godawat1990), number of pods per plant (Anil *et al.*, 1995; Satyawan *et al.*, 2004; Singh and Mir, 2005 and Singh and Singh 2006), number of seeds per pod and average seed weight (Anil *et al.*, 1995 and Tyagi and Srivastava, 2002) and seed yield per plant of pea (Mihailovic *et al.*, 1991and Narayan *et al.*, 1999). Meanwhile, Tyagi and Srivastava (2002) reported that a wide range of variability for seed yield and its components. They added that F_1 hybrids gave the highest range of variation compared to parents for number of pods per plant, number of seeds of per pod, seed weight and seed yield per plant. Singh and Singh (2003) indicated that additive and non-additive genetic variance were important in the inheritance of plant height and number of days to flowering in pea. On the other hand, additive genetic component was important in the expression of number of pods per plant and 100-seed weight (Singh and Singh, 2004). Ceyhan and Avei (2005) reported that additive and non-additive type of gene actions was important in expression of seed yield. Seem *et al.* (2005) found that genotypic coefficient of variation was high for plant height in pea. Recently, Singh and Singh (2006) reported that high coefficient of variation for plant height, number of pods per plant, 100-seed weight and seed yield per plant.

Over dominance and partial dominance played an important role in the inheritance of plant height (Zayed *et al.*, 2005), number of days to flowering in pea (Srivastava, *et al.*, 1986), number of pods per plant (Venkateswarlu and Singh, 1982 and Zayed *et al.*, 2005), dry pod weight (Hamed, 1999 on bean), number of seeds per pod (Anil *et al.*, 1993 and Vikas and Singh, 1999b), average seed weight (Gad and El-Sawah,1986) and dry seed yield per plant (Gad and El-Sawah, 1986 and Saxena *et al.*, 1988). While Panda *et al.* (1996) found over dominance for seed yield per plant. Zayed *et al.* (2005) reported that partial dominance which was responsible for the inheritance of plant height and number of pods per plant.

Heterosis were observed in different pea crosses for plant height (Sarawat *et al.*, 1994) and number of days to flowering (Moitra and Singh, 1986 and Om-Parakash *et al.*, 1993). Also heterosis were estimated for number of pods per plant (Arndt, 1980; Kharche and Narsinghani, 1994 and Sarawat *et al.*, 1994), dry pod weight (Hamad, 1976 and Hamed, 1999 on bean), number of seeds per pod (Arndt, 1980 and Pant and Bajpai, 1991), average seed weight (Moitra and Singh, 1986) and dry seed yield per plant (Singh *et al.*, 1994). However Tyagi and Srivastava (2001) revealed greater amount of heterosis over better parent in the crosses HUP2 x KPSD1, FC1 x T163 and FC1 x Pusa10 for seed yield per plant in pea. In addition Dipti *et al.* (2003) reported that the greatest heterosis was recorded for KS-226 x Azad p-3 in pea seed yield. Ceyhan and Avei (2005) and Zayed *et al.* (2005) found that maximum significant heterosis for earliness, number of seeds per pod and grain yield per plant. Inbreeding depression had been reported by Parmar (1993); Kharche and Narsinghani

(1994) and Tyagi and Srivastava (1999) who reported high positive inbreeding depression for seed yield.

High heritability in association with high genetic advance were observed for plant height (Singh *et al.*, 1993; Tyagi *et al.*, 1997 and Sureja and Sharma,2000) and number of days to flowering (Kumar *et al.*, 1997 and Gupta *et al.*, 1998). Meanwhile Singh and Singh (2004) found that high heritability values for growth characters. Also high heritability values were found for number of pods per plant (Vikas *et al.*,1996; Ramesh *et al.*,2002 and Singh *et al.*,2003), dry pod weight (Shinde, 2000 and Ramesh *et al.*, 2002), number of seeds per pod (Vikas *et al.*, 1996 and Singh *et al.*, 2003), average dry seed weight (Stelling,1988; Partap, 1992; Kumar *et al.*, 1997; Gupta *et al.*, 1998 and Singh *et al.*, 2003) and dry seed yield per plant (Stelling and Ebmeyer, 1990; Kumar *et al.*, 1997; Gupta *et al.*, 1998 and Shinde, 2000). However, Korla and Singh (1988) estimated moderate to high heritability values for number of seeds per pod. Singh and Singh (2004) indicated that heritability was high for number of pods per plant and 100-seed weight in F_1 and F_2 generations. The authors also added number of seeds per pod had moderate values of heritability in F_1 generation of pea. Recently, Singh and Mir (2005) and Singh and Singh (2006) found that high heritability estimates were predicted for plant height, days to 50%flowering, number of pods per plant and seed yield per plant.

The objective of the present investigation was to study the genetic performance for some growth and quality characters in order to develop successful selection strategy in the segregating generations of pea crosses which may lead to obtaining promising new lines or cultivars.

MATERIALS AND METHODS

This investigation was carried out at Sids Horticulture Research Station, Beni- Sueif Governorate, Egypt. Five pea (*Pisum sativum* L.) cultivars, namely Master B, Lincoln, Victory Freezer, Pss10699 and Bountiful were used in this study. Cultivars were grown each alone under open field conditions in two successive seasons to insure the purity of each parent before crossing. Cultivars were planted at two dates (31st October and 10th November 2000) to ensure the flowering periods in this genotypes. Six crosses and their reciprocals were made at flowering stage as follows:

Cross no 1: Master B x Pss10699
Cross no.2: Lincoln x Pss10699.
Cross no.3: Victory Freezer x Pss10699.
Cross no.4: Master B x Bountiful.
Cross no.5: Lincoln x Bountiful.
Cross no.6: Victory Freezer x Bountiful.

Flowers of female parents, i.e., Master, Lincoln and Victory Freezer were emasculated one day prior to anthesis and the pollen grains from the completely opened flowers of the male parents, i.e., Pss10699 and Bountiful were applied on the stigma to produce the F_1 seeds. Selected female parents on basis to high quality of pod characters. Seeds of the straight F_1 crosses were sown on 1st November 2001 to produce F_2 seeds. Seeds of parental, F_1, F_1r and F_2 populations for each crosses were sown on 15th November 2002 in a randomized complete block design with four replicates. Each of the parents, F_1 and F_1r was represented by a single row, while the F_2 populations were represented by two rows per block.. Each row was 4.5 m long and o.6 m wide. Individual seeds were sown at a distance of 25 cm apart. All cultural practices were applied according to the recommendations of Ministry of Agriculture. Data were recorded at harvesting time on individual plants from parents, F_1, F_1r and F_2 progenies in each cross for the following characters:

A-Vegetative and Flowering characters:

1-Plant height (cm.).

2-Number of days to flowering.

It was measured as the number of days from sowing until first flower anthesis.

B- Dry yield and its components:

1-Number of pods per plant.

2-Dry pod weight (gm.).

3-Number of seeds per pod.

It was measured as the mean of ten of pods per plant.

4-Dry seeds weight per pod (gm.).

5-Average seed weight (gm.).

6- Dry seed yield per plant (gm.).

Statistical analysis:

The genetic analysis were carried out on basis using several genetic methods as follow:

1- Mean standard deviation of the studied genotypes (Parents, F_1, F_1r and F_2 populations) was calculated according to Snedecor (1956).
Mean: $x = \sum F x / n$ where: $\sum$ means summation, F is the frequency, x is the class-center value and n is the total number of individual plants.

2- The coefficient of variance (C.V.%): was calculated according to the following formula.

$$C.V. = \sqrt{\frac{S^2}{\bar{X}}} \times 100$$

3- Standard error $(\overline{S\,x}) = S/\sqrt{n}$

4- Arithmetic and geometric gene action was estimated according to Powers Lyon (1941) as follows:

a-The expected arithmetic mean of the $F_1 = \frac{\overline{P_1}+\overline{P_2}}{2}$

b-The expected arithmetic mean of the $F_2 = \frac{\overline{P_1}+2\overline{F_1}+\overline{P_2}}{4}$

Where: P_1 = observed mean of one parent.

P_2 = observed mean of other parent.

F_1 = observed mean of the F_1 populations.

c- The expected geometric mean of the $F_1 = \sqrt{\overline{P_1}.\overline{P_2}}$

d- The expected geometric mean of the $F2 = \sqrt{\frac{1}{2}(\overline{P_1}+\overline{P_2}).\overline{F_1}}$

5- Relative potency of gene set was used to determine the direction of dominance according to the formula given by Mather and Jinks (1971), as follows:-

$$\text{Potency ratio} = \frac{\overline{F_1} - \overline{M.P}}{\frac{1}{2}(\overline{P_2} - \overline{P_1})}$$

Where:
$\overline{F_1}$= The observed mean of the F_1 population.
$\overline{M.P}$= The average of the observed means of the two parents.
$\overline{P_1}$= The observed mean of the low parent.
$\overline{P_2}$= The observed mean of the better parent.

6- Heterosis was calculated according to the following formula:

$$\text{Heterosis over the mid-parent (M.P)} = \frac{\overline{F_1} - \overline{M.P}}{\overline{M.P}} \times 100$$
(Sinha and Khanna, 1975)

$$\text{Heterosis over the high parent (H.P)} = \frac{\overline{F_1} - \overline{H.P}}{\overline{H.P}} \times 100$$
(Sinha and Khanna 1975)

where: $\overline{F_1}$, $\overline{M.P}$ and $\overline{H.P}$ are the means of F_1, mid parent and high parent, respectively.

7- Inbreeding depression was calculated according to Mather and Jinks (1971), as follows:

$$\text{Inbreeding depression (I.D.)} = \frac{\overline{F_2} - \overline{F_1}}{\overline{F_1}} \times 100$$

8- Broad sense heritability (BSH) was estimated according to equation:

$$B\,S\,H = \frac{V_G}{V_P} \times 100 \quad \text{(Allard, 1960)}$$

Where:
V_G = Genotypic variance which was calculated by subtracting the environmental variance (V_E) from phenotypic variance (V_P) = V_P-V_E
V_P = Phenotypic variance = (VF_2)
V_E = Environmental variance which was calculated as follows:

$$V_E = \frac{Vp_1+Vp_2+VF_1}{3}$$

The significance of means were determined using T- test.

RESULTS AND DISCUSSION

I - Vegetative and Flowering characters:

1- Plant height:

Data on plant height of parental, F_1, F_1r and F_2 populations of the crosses Master B x Pss10699, Lincoln x Pss10699, Victory Freezer x Pss10699, Master B x Bountiful, Lincoln x Bountiful and Victory Freezer x Bountiful are presented in Table (1). Parents were significantly different from each other in all crosses of this trait. In each cross, F_1 and F_2 means were intermediate between its two parents with a tendency towards the highest parent. High values of the coefficients of variability (Table, 1) were observed in population of F_2 than F_1 in all crosses. The F_2 populations exhibited a high variance in all crosses. These results are in accordance with that obtained by Seem *et al.* (2005) and Singh and Singh (2006) who found that high coefficient of variation for plant height of pea. Data of this character (Table, 2) showed that the observed F_2 mean of all crosses was relatively close to each of their expected arithmetic and geometric means which indicated that both of the additive and non- additive type of gene actions controlled the inheritance of plant height. These results are in agreement with those obtained by Sharma *et al.* (1999); Sharma and Rastogi (2001) and Singh and Singh (2003) who reported that additive and non-additive genetic variance were important in inheritance of plant height in peas. Data in Table (3) indicated that partial dominance towards the tall plants in the crosses Master B x Pss10699, Lincoln x Pss10699, Victory Freezer x Pss10699 and Victory Freezer x Bountiful, and partial dominance towards the short plants in the crosses Master B x Bountiful and Lincoln x Bountiful due to the exhibited value of potency ratio. These results are in agreement with those obtained by Zayed *et al.* (2005) indicated that plant height exhibited partial dominance in pea. Positive heterosis values (Table, 3) were observed in all crosses for this character except in the crosses Master B x Bountiful and Lincoln x Bountiful and ranged from 6.26% to 28.5% over mid parent. The highest value of heterosis (28.5%) was recorded in the cross Master B x Pss10699. On the other hand negative heterosis values were observed in all crosses and ranged from –28.99% to –12.06%over high parent. Positive inbreeding depression values (Table, 3) were observed for all crosses except in the crosses Master B x Pss10699 and Victory Freezer x Pss10699 and ranged from 6.58% to 11.55%. Concerning the heterosis result, Sarawat *et al.* (1994) who indicated that superiority of heterosis over mid parent and better parent in F_1 and F_2 of pea for plant height. Heritability (Table, 3) was relatively moderate to high values and ranged from 49.49 % to 71.90 % in all crosses, indicated that selection can be used for this character to be improve in these crosses. These results are in accordance with that obtained by Singh *et al.* (1993); Tyagi *et al.* (1997); Sureja and Sharma (2000) and Singh and Singh (2004) who estimated high heritability in broad sense values for this character. Singh and Mir (2005) and Singh and Singh (2006) stated that plant height exhibited high heritability values in F_2 of hybrids in field peas.

Table (1): Statistical constants of the plant height (cm) and number of days to flowering traits in parental, F_1, F_1r and F_2 populations of pea crosses.

Crosses	Characters	P_1	P_2	F_1	F_1r	F_2
Plant height (cm)						
Master (P_1) Pss10699 (P_2)	$\bar{X} \pm S_{\bar{X}}$	57. 1 ± 2.11	162.87 ± 4.04	141.33 ± 4.93	124.86 ± 2.53	125.10± 4.76
	C.V. %	20.21	13.61	19.12	11.11	32.05
	S^2	133.20	491.29	730.30	192.53	1607.58
No. of observed plants		30	30	30	30	71
Lincoln (P_1) Pss10699 (P_2)	$\bar{X} \pm S_{\bar{X}}$	69.77 ± 1.97	162.87 ± 4.04	123.60 ± 4.87	150.20± 3.90	137.88 ± 3.72
	C.V. %	15.48	13.61	21.59	14.25	21.92
	S^2	116.60	491.29	712.04	458.09	913.52
No. of observed plants		30	30	30	30	66
Victory Freezer (P_1) Pss10699 (P_2)	$\bar{X} \pm S_{\bar{X}}$	64.07 ± 2.02	162,87 ± 4.04	143.23 ± 6.73	154.0 ± 4.64	134.48 ± 4.49
	C.V. %	17.30	13.61	25.76	16.52	28.55
	S^2	122.82	491.29	1361.43	647.31	1473.81
No. of observed plants		30	30	30	30	73
Master (P_1) Bountiful (P_2)	$\bar{X} \pm S_{\bar{X}}$	57.1 ± 2.11	102.7 ± 4.92	78.00 ± 3.28	74.20 ± 2.94	83.70 ± 3.12
	C.V. %	20.21	26.23	23.06	21.68	33.38
	S^2	133.20	725.73	323.65	258.92	780.49
No. of observed plants		30	30	30	30	80
Lincoln (P_1) Bountiful (P_2)	$\bar{X} \pm S_{\bar{X}}$	69.77± 1.97	102.7 ± 4.92	72.93 ± 3.27	75.47 ± 3.61	77.73 ± 3.95
	C.V. %	15.48	26.23	24.60	26.22	42.84
	S^2	116.60	725.73	321.99	391.70	1108.71
No. of observed plants		30	30	30	30	71
Victory Freezer (P_1) Bountiful (P_2)	$\bar{X} \pm S_{\bar{X}}$	64.07 ± 2.02	102.7 ± 4.92	89.40 ± 5.28	89.40 ± 4.78	96.53 ± 4.31
	C.V. %	17.30	26.23	32.35	29.32	40.44
	S^2	122.82	725.73	836.52	687.14	1524.00
No. of observed plants		30	30	30	30	82
Number of days to flowering						
Master (P_1) Pss10699 (P_2)	$\bar{X} \pm S_{\bar{X}}$	45.00 ± 0.26	61.00 ± 0.39	57.80 ± 0.67	52.60 ± 0.34	53.30 ± 0.73
	C.V. %	3.20	3.50	6.33	3.59	14.92
	S^2	2.07	4.55	13.41	3.56	63.29
No. of observed plants		30	30	30	30	118
Lincoln (P_1) Pss10699 (P_2)	$\bar{X} \pm S_{\bar{X}}$	61.60 ± 0.40	61.00 ± 0.39	58.80 ± 0.43	62.80 ± 0.25	51.23 ± 0.73
	C.V. %	3.56	3.50	4.00	2.15	14.40
	S^2	4.80	4.55	5.54	1.82	54.42
No. of observed plants		30	30	30	30	102
Victory Freezer (P_1) Pss10699 (P_2)	$\bar{X} \pm S_{\bar{X}}$	64.40 ± 0.51	61.00 ± 0.39	59.20 ± 0.55	61.80 ± 0.43	55.49 ± 0.53
	C.V. %	4.31	3.50	5.14	3.80	10.26
	S^2	7.70	4.55	9.27	5.54	32.45
No. of observed plants		30	30	30	30	113
Master (P_1) Bountiful (P_2)	$\bar{X} \pm S_{\bar{X}}$	45.00 ± 0.26	66.5 ± 0.28	58.6 ± 0.45	58.4 ± 0.79	62.18 ± 0.34
	C.V. %	3.20	2.29	4.19	7.44	5.07
	S^2	2.07	2.33	6.04	18.87	9.93
No. of observed plants		30	30	30	30	85
Lincoln (P_1) Bountiful (P_2)	$\bar{X} \pm S_{\bar{X}}$	61.60 ± 0.40	66.50 ± 0.28	63.20 ± 0.34	63.20 ± 0.34	56.72 ± 0.51
	C.V. %	3.56	2.29	2.95	2.95	8.64
	S^2	4.80	2.33	3.48	3.48	24.01
No. of observed plants		30	30	30	30	92
Victory Freezer (P_1) Bountiful (P_2)	$\bar{X} \pm S_{\bar{X}}$	64.40 ± 0.51	66.50 ± 0.28	61.40± 0.44	61.80 ± 0.43	58.14 ± 0.54
	C.V. %	4.31	2.29	3.93	3.81	8.48
	S^2	7.70	2.33	5.83	5.54	24.32
No. of observed plants						

Table (2): Expected means of F_1 and F_2 populations in the growth characters for six crosses.

Characters	Arithmetic												Geometric											
	Cross No												Cross No											
	1		2		3		4		5		6		1		2		3		4		5		6	
	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2
Plant height (cm.)	109.98	125.66	116.32	119.96	113.47	128.35	79.90	78.95	86.23	79.58	83.38	86.39	96.44	124.68	106.60	119.90	102.15	127.48	76.58	78.94	84.65	79.30	81.12	86.34
Number of days to flowering	53.00	55.40	61.30	60.05	62.70	60.95	55.75	57.17	64.05	63.62	65.45	63.42	52.39	55.35	61.30	60.04	62.68	60.92	54.70	57.16	64.00	63.62	65.44	63.39

Table (3): Quantitative genetic parameters obtained for the growth characters of six crosses.

Parameters	Potency ratio						Heterosis (%)												I.D. (%)						Heritability (%)					
							M.P						H.P																	
Crosses / Characters	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
Plant height (cm.)	0.59	0.16	0.60	-0.08	-0.81	0.31	28.5	6.26	26.23	-2.38	-15.42	7.22	-13.22	-24.11	-12.06	-24.05	-28.99	-12.95	-11.48	11.55	-6.11	7.31	6.58	7.97	71.91	51.84	55.32	49.49	64.99	63.14
Number of days to flowering	0.60	-8.33	-2.06	0.26	-0.35	-3.86	9.06	-4.08	-5.58	5.11	-1.33	-6.19	-5.24	-4.53	-8.07	-11.88	-4.96	-7.67	-7.78	-12.87	-6.27	6.11	-10.25	-5.31	89.45	90.88	77.89	64.95	85.27	78.26

1-Cross no 1: Master B x Pss10699.
2-Cross no.2: Lincoln x Pss10699.
3-Cross no.3: Victory Freezer x Pss10699.
4-Cross no.4: Master B x Bountiful.
5-Cross no.5: Lincoln x Bountiful.
6-Cross no.6: Victory Freezer x Bountiful.

2-Number of days to flowering:

Data obtained on number of days to flowering of parental, F_1, F_1r and F_2 populations of all crosses are presented in Table (1). Parents were significantly different from each others in number of days to flowering in all crosses except in the cross Lincoln x Pss10699. The F_1 and F_2 means were intermediate between their parents with a tendency towards the highest parent in the crosses Master B x Pss10699 and Master B x Bountiful. While in the crosses Lincoln x Pss10699, Victory Freezer x Pss10699 and Victory Freezer x Bountiful were earlier than that of parents, also in the cross Lincoln x Bountiful, the F_1 mean was intermediate between their parents and the F_2 mean was lower than that of parents. High coefficient variability (Table, 1) was observed in population of F_2 in all crosses, indicating that the effects of both environment and genetics were involved in the inheritance of number of days to flowering. Moreover, the F_2 populations exhibited a high of variance in all crosses. The observed F_2 mean (Table, 2) of all crosses was relatively close to each of expected arithmetic and geometric means, indicated that additive and non- additive genetic variance were involved in the genetic behaviour of number of days to flowering. These results are in agreement with those obtained by Parmar and Godawat (1990) and Singh and Singh (2003) who reported that additive and non-additive gene were important for the number of days to flowering of peas. Data in Table (3), showed that the potency ratio exhibited a high value indicating over dominance for earliness of flowering in the crosses Lincoln x Pss10699, Victory Freezer x Pss10699 and Victory Freezer x Bountiful. While partial dominance for earliness of flowering in the cross Lincoln x Bountiful, and for high number of days to flowering in the crosses Master B x Pss10699 and Master B x Bountiful due to exhibited value of potency ratio. The observed different the nature of dominance could be due to influence of environmental effects on this character which differed in the different parental genotypes. These results are in agreement with those obtained by Srivastava *et al.* (1986) on pea, who found that over dominance and partial dominance was involved in the inheritance of number of days to flowering. Positive heterosis values (Table, 3) of 5.11% and 9.06% were found in the crosses Master B x Pss10699 and Master B x Bountiful over mid parent respectively. On the other hand negative heterosis values were found in all crosses based on high parent. These results partially agree with that of Moitra and Singh (1986) and Om-Parakash *et al.* (1993) who showed that negative heterosis of pea for this character. Ceyhan and Avei (2005) and Zayed *et al.* (2005) working on peas, found that significant heterosis for earliness. Moreover, positive inbreeding depression value was observed in the cross Master B x Bountiful, i. e., value of 6.11%. The broad sense heritability for this character (Table, 3), was high, being 77.89% to 90.88% in all crosses except in the cross Master B x Bountiful was moderate (64.95%). These results are in accordance with the findings of Kumar *et al.* (1997); Gupta *et at* (1998); Singh and Singh (2004); Singh and Mir (2005) and Singh and Singh (2006) who indicated that number of days to flowering exhibited high heritability of pea.

II-Yield and its components:

1-Number of pods per plant:

The data of this trait for all crosses are presented in Table (4). Parents were significantly different in number of pods per plant in all crosses except in the cross Master B x Bountiful. The F_1 mean was higher than its two parents in the crosses Lincoln x Pss10699, Victory Freezer x Pss10699 and Master B x Bountiful, while it was intermediate between its two parents in other crosses. The F_2 mean was intermediate between its two parents in all crosses except in the cross Master B x Bountiful where it was higher than their parents. The coefficients of variation of F_2 plants was higher than F_1 plants in all crosses indicating the existence of genetic and environmental variation affecting in this trait (Table, 4). In all crosses for this trait exhibited higher variance for F_2 populations than F_1. Similarly, Tyagi and Srivastava (2002) and Singh and Singh (2006) who found that number of pods per plant exhibited high coefficient of variation of peas. Data in (Table, 5) indicated that the observed F_2 mean of all crosses was relatively close to each of their expected arithmetic and geometric means which indicated that both of the additive and non- additive type of gene actions controlled the inheritance of this character. This agrees with the findings of Anil *et al.* (1995); Satyawan *et al.* (2004); Singh and Singh (2004) and Singh and Mir (2005) who noticed that additive and non- additive gene actions were important in the inheritance of this trait. These results were confirmed by the high value of the potency ratio (Table, 6) which indicated presence of an over dominance towards the high number of pods per plant in the crosses Lincoln x Pss10699, Victory Freezer x Pss10699 and Master B x Bountiful. These results are in agreement with those reported by Venkateswarlu and Singh (1982) found that over dominance for number of pods /plant. On the other hand, partial dominance towards the high number of pods per plant was found for other studied crosses due to exhibited value of potency ratio for this character. The observed different the nature of dominance could be due to influence of environmental effects on expression of this character which differed in the different parental genotypes. Similarly, Zayed *et al.* (2005) reported that partial dominance for number of pods/plant. High positive heterosis (Table, 6) was observed in the cross Master B x Bountiful for both mid-parent and high parent (88.63% and 80.69% respectively). However high value inbreeding depression (21.37%) was found in this cross. Concerning the heterosis result, Arndt (1980); Kharche and Narsinghani (1994) and Sarawat *et al.* (1994) who found that significant heterosis for number of pods/plant of pea. Heritability estimated for this character (Table, 6) ranged from 34.72% to 83.39%. The higher value of heritability was observed in the cross Master B x Bountiful (83.39%), indicated that selection can be used for this character to be improve in this cross. These results, are in accordance with that obtained by Vikas *et al.* (1996); Ramesh *et al.* (2002); Singh *et al.* (2003); Singh and Singh (2004); Singh and Mir (2005) and Singh and Singh (2006) on pea, who observed that heritability was high for this trait.

2-Dry pod weight:

Data on dry pod weight of parental, F_1, F_1r and F_2 population of all crosses are presented in Table (4). Parents were significantly different in dry pod weight in all crosses. The F_1 mean was intermediate between its two parents in all crosses except in the cross Victory Freezer x Bountiful where it was higher than the two parents. While F_2 mean was higher than its two parents in the crosses Victory Freezer x Pss10699, Lincoln x Bountiful and Victory Freezer x Bountiful and it was intermediate between two parents in the other crosses. The coefficient of variation of F_2 populations was higher than parents and F_1 plants in all crosses, Table (4): Statistical constants of number of pods /plant and dry pod weight (gm.) traits in parental, F_1, F_1r and F_2 populations of pea crosses.

Crosses	Characters	P_1	P_2	F_1	F_1r	F_2
Number of pods /plant						
Master (P_1) Pss10699 (P_2)	$\bar{X} \pm S_{\bar{x}}$	37.00± 3.73	128.00 ± 8.23	123.00 ± 10.69	95.00 ±7.95	101.86 ± 6.71
	C.V. %	55.25	35.22	47.64	45.87	64.79
	S^2	417.93	2032.76	3434.48	1899.31	4355.99
No. of observed plants		30	30	30	30	97
Lincoln (P_1) Pss10699 (P_2)	$\bar{X} \pm S_{\bar{x}}$	91.00±7.73	128.00 ± 8.23	139.00 ±11.65	121.47±12.69	102.41±7.23
	C.V. %	46.57	35.22	45.95	57.26	65.14
	S^2	1795.86	2032.76	4080.00	4837.45	4450.84
No. of observed plants		30	30	30	30	85
Victory Freezer (P_1) Pss10699 (P_2)	$\bar{X} \pm S_{\bar{x}}$	70.46 ± 8.77	128.00 ± 8.23	139.00± 9.06	167.00± 13.36	91.48 ± 6.96
	C.V. %	68.25	35.22	35.73	43.85	72.98
	S^2	2312.53	2032.76	2466.21	5362.76	4457.00
No. of observed plants		30	30	30	30	92
Master (P_1) Bountiful (P_2)	$\bar{X} \pm S_{\bar{x}}$	37.00 ± 3.73	40.40 ± 3.64	73.00 ± 5.25	47.47±4.15	88.60± 6.03
	C.V. %	55.25	49.39	39.41	47.90	64.82
	S^2	417.93	398.11	827.59	517.15	3298.24
No. of observed plants		30	30	30	30	91
Lincoln (P_1) Bountiful (P_2)	$\bar{X} \pm S_{\bar{x}}$	91.00 ± 7.73	40.40 ± 3.64	81.00± 4.30	47.00 ± 3.01	78.23 ± 4.85
	C.V. %	46.57	49.39	29.07	35.16	58.11
	S^2	1795.86	398.11	554.48	273.10	2066.61
No. of observed plants		30	30	30	30	88
Victory Freezer (P_1) Bountiful (P_2)	$\bar{X} \pm S_{\bar{x}}$	70.46 ± 8.77	40.40 ± 3.64	69.00 ± 7.75	91.00 ± 6.25	67.47 ± 5.21
	C.V. %	68.25	49.39	61.58	37.67	71.17
	S^2	2312.53	398.11	1805.48	1175.17	2305.97
No. of observed plants		30	30	30	30	85
Dry pod weight (gm)						
Master (P_1) Pss10699 (P_2)	$\bar{X} \pm S_{\bar{x}}$	1.21± 0.048	0.45± 0.026	0.79± 0.026	0.89± 0.032	1.03± 0.037
	C.V. %	21.86	31.43	17.90	19.46	33.63
	S^2	0.07	0.02	0.02	0.03	0.12
No. of observed plants		30	30	30	30	85
Lincoln (P_1) Pss10699 (P_2)	$\bar{X} \pm S_{\bar{x}}$	0.91± 0.032	0.45± 0.026	0.67± 0.026	0.80± 0.052	0.86± 0.033
	C.V. %	19.03	31.43	21.11	35.35	32.89
	S^2	0.03	0.02	0.02	0.08	0.08
No. of observed plants		30	30	30	30	75
Victory Freezer (P_1) Pss10699 (P_2)	$\bar{X} \pm S_{\bar{x}}$	0.79± 0.026	0.45± 0.026	0.68± 0.036	0.63± 0.041	0.93± 0.033
	C.V. %	17.90	31.43	29.41	35.49	32.26
	S^2	0.02	0.02	0.04	0.05	0.09
No. of observed plants		30	30	30	30	83
Master (P_1) Bountiful (P_2)	$\bar{X} \pm S_{\bar{x}}$	1.21± 0.048	0.68± 0.032	1.08± 0.036	1.13± 0.055	0.93± 0.037
	C.V. %	21.86	25.47	18.52	26.54	35.66
	S^2	0.07	0.03	0.04	0.09	0.11
No. of observed plants		30	30	30	30	79
Lincoln (P_1) Bountiful (P_2)	$\bar{X} \pm S_{\bar{x}}$	0.91± 0.032	0.68± 0.032	0.89± 0.036	0.79± 0.032	0.92± 0.032
	C.V. %	19.03	25.47	22.47	21.92	30.74
	S^2	0.03	0.03	0.04	0.03	0.08
No. of observed plants		30	30	30	30	79
Victory Freezer (P_1) Bountiful (P_2)	$\bar{X} \pm S_{\bar{x}}$	0.79± 0.026	0.68± 0.032	0.80± 0.026	1.13± 0.036	0.84± 0.033
	C.V. %	17.90	25.47	17.68	17.70	35.71
	S^2	0.02	0.03	0.02	0.04	0.09
No. of observed plants		30	30	30	30	80

Table (5): Expected means of F_1 and F_2 populations for six crosses in the quality characters.

Characters	Arithmetic												Geometric											
	Cross No												Cross No											
	1		2		3		4		5		6		1		2		3		4		5		6	
	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2
Number of pod per plant	82.50	102.75	109.5	124.25	99.23	119.11	38.70	55.85	65.70	73.35	55.43	62.22	68.82	100.73	107.92	123.37	94.97	117.44	38.66	53.15	60.63	72.95	53.36	61.85
Dry pod weight (gm.)	0.83	0.81	0.68	0.67	0.62	0.65	0.94	1.01	0.79	0.84	0.73	0.77	0.74	0.81	0.64	0.67	0.60	0.65	0.91	1.01	0.79	0.84	0.73	0.77
Number of seeds per pod	5.63	4.95	5.00	4.73	4.97	4.72	5.80	5.73	5.16	5.38	5.13	5.00	5.49	4.90	4.96	4.73	4.93	4.71	5.69	5.73	5.14	5.38	5.12	5.00
Dry seeds weight per pod (gm.)	0.64	0.55	0.50	0.51	0.44	0.44	0.70	0.78	0.56	0.60	0.50	0.51	0.56	0.54	0.47	0.51	0.43	0.44	0.65	0.78	0.55	0.60	0.50	0.51
Average seed weight (gm.)	0.10	0.10	0.09	0.10	0.09	0.09	0.11	0.14	0.11	0.11	0.10	0.10	0.10	0.10	0.09	0.10	0.08	0.09	0.11	0.13	0.11	0.11	0.10	0.10
Dry seed yield per plant (gm.)	37.63	46.18	51.56	63.92	43.01	55.84	29.08	43.18	43.01	50.77	34.46	37.00	37.63	45.38	49.46	62.71	42.59	54.35	27.60	40.81	36.28	50.18	31.24	36.91

1-Cross no 1: Master B x Pss10699.
2-Cross no.2: Lincoln x Pss10699.
3-Cross no.3: Victory Freezer x Pss10699.
4-Cross no.4: Master B x Bountiful.
5-Cross no.5: Lincoln x Bountiful.
6-Cross no.6: Victory Freezer x Bountiful.

Table (6): Quantitative genetic parameters obtained for the quality characters of six crosses.

Parameters	Potency ratio						Heterosis (%) M.P						Heterosis (%) H.P						I.D. (%)						Heritability (%)					
Characters \ Crosses	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
Number of pods per plant	0.89	1.59	1.38	20.18	0.60	0.90	49.09	26.94	40.08	88.63	23.29	24.48	-3.91	8.59	8.59	80.69	-10.99	-2.07	-17.19	-26.32	-34.19	21.37	-3.42	-2.22	54.96	40.77	49.06	83.39	55.67	34.72
Dry pod weight (g m.)	-0.10	-0.04	0.35	0.51	0.83	1.18	-4.82	-1.47	9.68	14.89	12.66	9.59	-34.71	-26.37	-13.92	-10.74	-2.20	-1.26	30.38	28.36	36.76	-13.89	3.37	5.00	69.17	71.25	70.00	57.27	58.75	74.44
Number of seeds per pod	-1.07	-0.84	-0.87	-0.12	0.96	-0.60	-24.16	-10.60	-10.06	-2.24	8.53	-5.07	-38.11	-20.60	-19.75	-17.83	-0.53	-12.57	12.18	16.33	2.46	-14.28	-2.86	-0.82	69.52	64.52	62.71	52.36	66.53	55.49
Dry seeds weight per pod (g m.)	-0.60	0.03	-0.04	0.58	0.60	0.23	-30.23	0.99	-1.12	21.98	13.27	2.97	-53.61	-26.09	-22.81	-11.34	-7.25	-8.77	13.33	7.84	2.27	-22.09	-9.37	13.46	40.00	42.50	61.67	37.33	61.43	66.00
Average seed weight (g m.)	0.13	1.19	0.60	2.62	0.57	2.33	3.96	27.17	10.46	36.52	3.77	3.48	-19.85	3.54	-6.86	19.85	-2.65	1.96	18.09	4.27	26.31	-10.83	12.73	5.77	54.61	58.00	68.82	62.07	21.43	42.73
Dry seed yield per plant (gm.)	26.93	1.70	4.27	3.07	0.67	0.35	45.44	47.92	59.66	96.94	36.08	14.71	43.01	15.33	40.06	49.65	-11.49	-19.37	45.86	12.35	19.19	12.52	9.40	59.02	86.47	59.21	64.03	77.77	57.33	70.6

1-Cross no 1: Master B x Pss10699.
2-Cross no.2: Lincoln x Pss10699.
3-Cross no.3: Victory Freezer x Pss10699.
4-Cross no.4: Master B x Bountiful.
5-Cross no.5: Lincoln x Bountiful.
6-Cross no.6: Victory Freezer x Bountiful.

indicating the existence of genetic and environmental variation affecting this character (Table, 4). All the studied crosses showed high values of variance for this character. The observed F_2 mean (Tables, 5) of all crosses was relatively close to the arithmetic and geometric means, this indicated that dry pod weight is controlled by genes additive and non- additive effects. Data in Table (6) indicated over dominance towards the high dry pod weight in the cross Victory Freezer x Bountiful, due to the high value of potency ratio, while partial dominance for high dry pod weight in the crosses Victory Freezer x Pss10699, Master B x Bountiful and Lincoln x Bountiful, and for low dry pod weight in the two other crosses due to exhibited value of potency ratio. The observed different the nature of dominance could be due to influence of environmental effects on this character which differed in the different parental genotypes. This agreed with the findings of Hamed (1999) in beans. Positive heterosis was recorded over mid parent in the crosses Victory Freezer x Pss10699, Master B x Bountiful, Lincoln x Bountiful and Victory Freezer x Bountiful (Table, 6). Moreover, negative heterosis over high parent was recorded in all crosses for this trait. These results are in agreement with those obtained by Hamad (1976) and Hamed (1999) who stated that some crosses manifested positive heterosis while the most crosses exhibited negative one for pod weight of bean. The inbreeding depression values (Table, 6) ranged from –13.89 % to 36.76 % for all crosses. The cross Master B x Bountiful exhibited negative value of (-13.89%) inbreeding depression. Estimates of heritability for this trait (Table, 6) ranged from 57.27 % to 74.44 %. The cross Victory Freezer x Bountiful gave the highest heritability. These results were in agreement with that obtained by Shinde (2000) and Ramesh *et al.* (2002) who reported that the heritability values were found to be high for the dry pod weight in peas.

3-Number of seeds per pod:

The genetic parameters estimated for this character are presented in Table (7). Parents were significantly different from each others in all crosses. The F_1 and F_2 means were intermediate between its two parents in all crosses except in the cross Master B x Pss10699 where its F_1 mean was lower than both parents. A higher values of coefficient of variation was found for F_2 than F_1 plants in all crosses indicating the existence of genetic and environmental variation affecting this trait (Table, 7). Moreover, higher variance value was detected for F_2 plants in all crosses. These results are quite similar to those reported by Tyagi and Srivastava (2002) found that a w: le range of variability for number of seeds per pod of pea. Data in (Table, 5) showed that the observed F_2 mean of all crosses was relatively close to arithmetic and geometric means, indicated both of the additive and non-additive type of gene actions controlled the inheritance of this character. This result agreed with the findings of Anil *et al.* (1995) who indicated that additive and non-additive genetic variances were involved in the genetic behaviour of number of seeds per pod in pea. Different types of dominance, i.e., over dominance for low number of seeds per pod in the cross Master B x Pss10699, partial dominance for high number of seeds per pod in the cross Lincoln x Bountiful, and for low number of seeds per pod in the other crosses (Table, 6). The observed different the nature of dominance could be due to influence of environmental effects on this character which differed in the different parental genotypes. This result agreed with the findings of Anil *et al.* (1993) and Vikas and Singh (1999b).on peas, reported that number of seeds/pod was controlled by dominance gene action. Positive heterosis (Table, 6) was recorded over mid parent in cross Lincoln x Bountiful (8.53%), while negative heterosis was found over high parent in the all crosses which ranged from -38.11% to -0.53 %. These results are in agreement with those obtained by Arndt (1980); Pant and Bajpai (1991); Ceyhan and Avei (2005) and Zayed *et al.* (2005) who reported that number of seeds per pod exhibited maximum significant heterosis in pea. Positive inbreeding depression was observed in the crosses Master B x Pss10699, Lincoln x Pss10699 and Victory Freezer x Pss10699 only (Table, 6). Estimates of broad sense heritability for number of seeds per pod (Table, 6) ranged from 52.36 % to 69.52 %, the cross Master B x Pss10699 gave the highest values of heritability. These results indicated the great role of the environment on the inheritance of this trait. High heritability estimates obtained by Vikas *et al.* (1996); Singh *et al.* (2003) and Singh and Singh (2004) on pea, while medium to high heritability estimates were obtained by Korla and Singh (1988) on pea.

4-Dry seeds weight per pod:

Data on dry pod seeds weight of parental, F_1, F_1r and F_2 populations of all crosses are shown in Table (7). Parents were significantly different in dry seeds weight in all crosses. The F_1 and F_2 means were intermediate between their parents in all crosses except in the cross Victory Freezer x Bountiful where the F_2 mean was higher than its two parents. High values of the coefficient of variability (Table, 7) were observed in the segregating population of F_2 than F_1 in all crosses. The F_2 plants gave high variance in all crosses (Table, 7) which indicated the existence of genetic and environmental variation for this trait. Data in Table (5), showed that the observed F_2 mean was relatively close to the arithmetic and geometric means of all crosses, indicated that both of the additive and non-additive type of gene actions controlled the inheritance of this character. Quantitative genetic parameters obtained for dry seeds weight per pod are shown in Table (6).The estimated potency of gene set confirmed the partial dominance for high dry seeds weight per pod in the crosses Lincoln x Pss10699, Master B x Bountiful, Lincoln x Bountiful and Victory Freezer x Bountiful, and for low dry seeds weight per pod in the crosses Master B x Pss10699 and Victory Freezer x Pss10699. Positive heterosis for this trait (Table, 6) was found in all crosses, except in the crosses Master B x Pss10699 and Victory Freezer x Pss10699, which ranged from 0.99% to 21.98% over mid parent. At the same time, negative heterosis was observed in all crosses over high parent. Positive inbreeding depression values for this character were achieved in all crosses (Table, 6) except in the crosses Master B x Bountiful and Lincoln x Bountiful where it was negative which ranged from (2.27 % to 13.46 %). Heritability was moderate for this character (Table, 6) which ranged from 61.43% to 66.00% in the crosses Victory Freezer x Pss10699, Lincoln x Bountiful and Victory Freezer x Bountiful. While it was low in the other crosses.

5-Average seed weight:

Data for average seed weight of the studied genotypes are shown in Table (8). In all crosses parents were significantly different in average seed weight, except in the crosses Lincoln x Bountiful and Victory Freezer x Bountiful. The F_1 mean was higher than their parents in the crosses Lincoln x Pss10699, Master B x Bountiful and Victory Freezer x Bountiful, and it was intermediate between the two parents in the other crosses. The F_2 mean was higher than its two parents in all crosses except in the cross Master B x Pss10699 where it was intermediate between its two parents with a tendency towards the highest parent, indicating the existence of genetic and environmental variation affecting this character. Coefficient variability of F_2 populations of (Table, 8) was higher than that of F_1 population in all crosses. The analysis of variance for these genotypes showed that F_2 variance was higher than that of F_1 in all crosses. This result agrees with the findings of Tyagi and Srivastava (2002) and Singh and Singh (2006) who showed that high coefficient of variation for 100- seed weight of pea. The Observed F_2 mean (Table, 5) of all crosses was relatively close to each of their expected arithmetic and geometric means revealing that this character was controlled by additive and non- additive gene effects. These results were in accordance with estimates of Anil *et al.* (1995) and Singh and Singh (2004) who reported that additive and non- additive gene were important for this character of pea. Data in (Table 6), indicated that over dominance towards heavy seed weight in the crosses Lincoln x Pss10699, Master B x Bountiful and Victory Freezer x Bountiful due to the high value of potency ratio. While partial dominance towards the high seed weight in the crosses Master B x Pss10699, Victory Freezer x Pss10699 and Lincoln x Bountiful due to the exhibited value of potency ratio. The observed different the nature of dominance could be due to influence of environmental effects on this character which differed in the different parental genotypes. This result agrees with the findings of Gad and El-Sawah (1986) who observed different degree of dominance for 100-seed weight of pea. High positive heterosis (Table, 6) was obtained in the cross Master B x Bountiful (36.52%) over mid parent and (19.85%) over high parent. Variable results of heterosis for average seed weight have been also reported by Moitra and Singh (1986) who found negative heterosis for seed weight in most studied crosses of pea. Positive inbreeding depression (Table, 6) was observed of in all crosses which ranged from 4.27% to 26.31%, except in the cross Master B x Bountiful where it was negative for this trait. The broad sense heritability for this character (Table, 6) was above low to moderate in all crosses which ranged from 21.43 % to 68.82 %, except in the cross Lincoln x Bountiful which was low. Whereas Stelling (1988); Partap *et al.* (1992); Kumar *et al.* (1997); Gupta *et al.* (1998); Singh *et al.* (2003) and Singh and Singh (2004) who indicated that heritability for mean seed weight was high of pea.

6-Dry seed yield per plant:

Data obtained on dry seed yield per plant of parental, F_1, F_{1r} and F_2 populations of all crosses are presented in Table (8). Parents were significantly different in all crosses for this character except in the cross Master B x Pss10699. The F_1 mean was higher than its two parents in all crosses except in the crosses Lincoln x Bountiful and Victory Freezer x Bountiful where it was intermediate between their parents. The F_2 mean was higher than its two parents in all crosses except in the cross Lincoln x Bountiful where it was intermediate between their parents. The coefficient of variation (Table, 8) of F_2 plants was higher than F_1 plants in all crosses. indicating the existence of genetic and environmental variation affecting this character. The F_2 populations had high variance value (Table, 8) in all crosses. These results are in accordance with those obtained by Tyagi and Srivastava (2002) and Singh and Singh

(2006) who noticed that seed yield per plant exhibited high coefficient of variation of pea. Data in Table (5) showed that the observed F_2 mean of all crosses was relatively close to each of their expected arithmetic and geometric means which indicated that both of the additive and non-additive type of gene actions controlled the inheritance of this character. These results are in agreement with Mihailovic *et al.* (1991); Narayan *et al.* (1999) and Ceyhan and Avei (2005) who observed that additive and non-additive gene actions were important in the inheritance of dry seed yield/plant in peas. Data obtained on potency ratio (Table, 6) indicated over dominance for high seed yield per plant in the crosses Master B x Pss10699, Lincoln x Pss10699, Victory Freezer x Pss10699 and Master B x Bountiful due to the high value of potency ratio, while partial dominance for high seed yield per plant in the crosses Lincoln x Bountiful and Victory Freezer x Bountiful due to exhibited value of potency ratio. The observed different the nature of dominance could be due to influence of environmental effects on the expression of this character which differed in the different parental genotypes. These results coincided with that obtained by Gad and El-Sawah (1986); Saxena (1988) and Panda *et al.* (1996) on pea, found over dominance for yield/plant. Positive heterosis (Table, 6) was found in all crosses and ranged from 14.71% to 96.94 % for mid parant. Moreover, negative heterosis was observed in the crosses Lincoln x Bountiful and Victory Freezer x Bountiful over high parent for this trait. The cross Master B x Bountiful had the highest value of 96.94 % and 49.65% based on mid-parent and high parent, respectively. These results are in agreement with previous results obtained on this trait by Singh *et al.* (1994) and Tyagi and Srivastava (2001) who noticed that high heterosis for seed yield /plant of peas. Dipti *et al.* (2003) on pea, showed that hybrid KS-226 x Azad P-3 had the greatest heterosis for dry seed yield per plant (55.37 %). Ceyhan and Avei (2005) and Zayed *et al.* (2005) showed high significant heterosis over mid-parent and over better parent for pea seed yield. Positive inbreeding depression (Table, 6) was found in all crosses and ranged 9.40 % to 59.02 %. This is in agreement with the findings of Parmar (1993); Kharche and Narsinghani (1994) and Tyagi and Srivastava (1999) who indicated high positive inbreeding depression for pea yield. Heritability (Table, 6) was a moderate to high values, ranging from 57.33% to 86.47 %, indicating that selection in early segregating generation would be moderate to high effective. The crosses Master B x Pss10699, Master B x Bountiful and Victory Freezer x Bountiful showed high heritability values for dry seed yield. These results agree with that obtained by Stelling and Ebmeyer (1990); Kumar *et al.* (1997); Gupta *et al.* (1998); Shinde (2000);Singh and Mir (2005) and Singh and Singh (2006) working on pea, who estimated high heritability values for seed yield/plant.

CONCLUSION

In general, it can be concluded that additive or non-additive and dominance effects played the important role in inheritance of all the previous characters. Moreover, the high estimates of broad-sense heritability for most studied traits indicated that selection can be used for improving of these characters in peas. Also, the genetic analysis demonstrated that a considerable amount of readily fixable variation is present and available for the plant breeder to manipulate.

Table (7): Statistical constants of the number of seeds per pod and dry seeds weight per pod (gm.) traits in parental, F_1, F_1r and F_2 populations of pea crosses.

Crosses	Characters	P_1	P_2	F_1	F_1r	F_2
Number of seeds per pod						
Master (P_1) Pss10699 (P_2)	$\bar{X} \pm S_{\bar{x}}$	6.90± 0.12	4.37± 0.17	4.27± 0.16	5.53± 0.08	4.79± 0.16
	C.V. %	9.61	22.07	20.28	7.67	31.80
	S^2	0.44	0.93	0.75	0.18	2.32
No. of observed plants		30	30	30	30	91
Lincoln (P_1) Pss10699 (P_2)	$\bar{X} \pm S_{\bar{x}}$	5.63± 0.15	4.37± 0.17	4.47± 0.19	4.67± 0.24	5.20± 0.18
	C.V. %	14.32	22.07	23.25	28.33	30.41
	S^2	0.65	0.93	1.08	1.75	2.50
No. of observed plants		30	30	30	30	78
Victory Freezer (P_1) Pss10699 (P_2)	$\bar{X} \pm S_{\bar{x}}$	5.57± 0.11	4.37± 0.17	4.47± 0.15	4.80± 0.12	4.58± 0.16
	C.V. %	11.21	22.07	18.17	13.82	29.05
	S^2	0.39	0.93	0.66	0.44	1.77
No. of observed plants		30	30	30	30	72
Master (P_1) Bountiful (P_2)	$\bar{X} \pm S_{\bar{x}}$	6.90± 0.12	4.70± 0.17	5.67± 0.24	5.73± 0.23	4.86± 0.17
	C.V. %	9.61	19.50	23.33	22.21	29.96
	S^2	0.44	0.84	1.75	1.62	2.12
No. of observed plants		30	30	30	30	74
Lincoln (P_1) Bountiful (P_2)	$\bar{X} \pm S_{\bar{x}}$	5.63± 0.15	4.70± 0.17	5.60± 0.16	5.47± 0.27	5.44± 0.17
	C.V. %	14.32	19.50	15.97	27.05	27.76
	S^2	0.65	0.84	0.80	2.19	2.28
No. of observed plants		30	30	30	30	75
Victory Freezer (P_1) Bountiful (P_2)	$\bar{X} \pm S_{\bar{x}}$	5.57± 0.11	4.70± 0.17	4.87± 0.19	6.07± 0.23	4.83± 0.14
	C.V. %	11.21	19.50	21.34	20.97	27.23
	S^2	0.39	0.84	1.08	1.62	1.73
No. of observed plants		30	30	30	30	87
Dry seeds weight per pod (gm.)						
Master (P_1) Pss10699 (P_2)	$\bar{X} \pm S_{\bar{x}}$	0.97± 0.041	0.32± 0.018	0.45± 0.032	0.71± 0.032	0.51± 0.025
	C.V. %	23.05	31.25	38.49	24.39	43.84
	S^2	0.05	0.01	0.03	0.03	0.05
No. of observed plants		30	30	30	30	81
Lincoln (P_1) Pss10699 (P_2)	$\bar{X} \pm S_{\bar{x}}$	0.69± 0.032	0.32± 0.018	0.51± 0.032	0.55± 0.026	0.55± 0.021
	C.V. %	25.10	31.25	33.96	25.71	36.36
	S^2	0.03	0.01	0.03	0.02	0.04
No. of observed plants		30	30	30	30	89
Victory Freezer (P_1) Pss10699 (P_2)	$\bar{X} \pm S_{\bar{x}}$	0.57± 0.026	0.32± 0.018	0.44 ± 0.036	0.46± 0.041	0.45± 0.024
	C.V. %	24.81	31.25	45.45	48.61	54.43
	S^2	0.02	0.01	0.04	0.05	0.06
No. of observed plants		30	30	30	30	106
Master (P_1) Bountiful (P_2)	$\bar{X} \pm S_{\bar{x}}$	0.97± 0.041	0.44 ± 0.026	0.86± 0.048	0.79± 0.052	0.67± 0.030
	C.V. %	23.05	32.14	30.76	36.47	40.87
	S^2	0.05	0.02	0.070	0.083	0.075
No. of observed plants		30	30	30	30	83
Lincoln (P_1) Bountiful (P_2)	$\bar{X} \pm S_{\bar{x}}$	0.69± 0.032	0.44 ± 0.026	0.64 ± 0.032	0.61± 0.032	0.58 ± 0.029
	C.V. %	25.10	32.14	27.06	28.39	45.62
	S^2	0.03	0.02	0.03	0.03	0.07
No. of observed plants		30	30	30	30	81
Victory Freezer (P_1) Bountiful (P_2)	$\bar{X} \pm S_{\bar{x}}$	0.57± 0.026	0.44 ± 0.026	0.52± 0.018	0.57± 0.026	0.59± 0.026
	C.V. %	24.81	32.14	19.23	24.81	37.90
	S^2	0.02	0.02	0.01	0.02	0.05
No. of observed plants		30	30	30	30	74

Table (8): Statistical constants of the average seed weight (gm.) and dry seed yield per plant traits in parental, F_1, F_1r and F_2 populations of pea crosses.

Crosses	Characters	P_1	P_2	F_1	F_1r	F_2
Average seed weight (gm.)						
Master (P_1) / Pss10699 (P_2)	$\bar{X} \pm S_{\bar{X}}$	0.131± 0.006	0.071± 0.002	0.105± 0.043	0.131± 0.007	0.124± 0.004
	C.V. %	24.14	19.92	22.54	28.56	29.08
	S^2	0.001	0.0002	0.00056	0.0014	0.0013
No. of observed plants		30	30	30	30	83
Lincoln (P_1) / Pss10699 (P_2)	$\bar{X} \pm S_{\bar{X}}$	0.113± 0.006	0.071± 0.002	0.117± 0.005	0.122± 0.008	0.122± 0.004
	C.V. %	27.98	19.92	22.61	36.65	31.74
	S^2	0.001	0.0002	0.0007	0.002	0.0015
No. of observed plants		30	30	30	30	94
Victory Freezer (P_1) / Pss10699 (P_2)	$\bar{X} \pm S_{\bar{X}}$	0.102± 0.004	0.071± 0.002	0.095± 0.005	0.106± 0.005	0.120± 0.004
	C.V. %	24.01	19.92	29.77	26.68	34.36
	S^2	0.0006	0.0002	0.0008	0.0008	0.0017
No. of observed plants		30	30	30	30	94
Master (P_1) / Bountiful (P_2)	$\bar{X} \pm S_{\bar{X}}$	0.131± 0.006	0.099 ± 0.005	0.157± 0.007	0.134± 0.008	0.140± 0.005
	C.V. %	24.14	30.30	24.67	33.37	38.46
	S^2	0.001	0.0009	0.0015	0.002	0.0029
No. of observed plants		30	30	30	30	114
Lincoln (P_1) / Bountiful (P_2)	$\bar{X} \pm S_{\bar{X}}$	0.113± 0.006	0.099± 0.005	0.110± 0.005	0.109± 0.004	0.124± 0.004
	C.V. %	27.98	30.30	27.27	20.51	30.17
	S^2	0.0015	0.0009	0.0009	0.0005	0.0014
No. of observed plants		30	30	30	30	90
Victory Freezer (P_1) / Bountiful (P_2)	$\bar{X} \pm S_{\bar{X}}$	0.102± 0.004	0.099± 0.005	0.104± 0.004	0.131± 0.004	0.110± 0.004
	C.V. %	24.01	30.30	19.23	18.70	30.15
	S^2	0.0006	0.0009	0.0004	0.0006	0.0011
No. of observed plants		30	30	30	30	81
Dry seed yield per plant						
Master (P_1) / Pss10699 (P_2)	$\bar{X} \pm S_{\bar{X}}$	38.27 ± 3.27	37.00 ± 3.15	54.73 ± 3.24	75.27 ± 6.75	79.83 ± 4.49
	C.V. %	46.89	46.71	32.43	48.49	60.14
	S^2	321.99	298.76	314.96	1367.65	2305.36
No. of observed plants		30	30	30	30	114
Lincoln (P_1) / Pss10699 (P_2)	$\bar{X} \pm S_{\bar{X}}$	66.13 ± 6.48	37.00 ± 3.15	76.27 ± 6.62	81.33 ± 4.58	85.69 ± 4.58
	C.V. %	53.74	46.71	47.60	30.88	56.61
	S^2	1263.08	298.76	1317.86	630.71	2353.21
No. of observed plants		30	30	30	30	112
Victory Freezer (P_1) / Pss10699 (P_2)	$\bar{X} \pm S_{\bar{X}}$	49.03 ± 3.81	37.00 ± 3.15	68.67 ± 5.71	75.00 ± 4.64	81.85 ± 3.78
	C.V. %	42.55	46.71	45.55	33.92	48.67
	S^2	435.27	298.76	978.44	647.31	1587.04
No. of observed plants		30	30	30	30	111
Master (P_1) / Bountiful (P_2)	$\bar{X} \pm S_{\bar{X}}$	38.27 ± 3.27	19.90 ± 1.39	57.27 ± 3.96	54.73 ± 5.21	64.44 ± 3.44
	C.V. %	46.89	38.44	37.91	52.16	55.47
	S^2	321.99	58.51	471.37	814.96	1277.56
No. of observed plants		30	30	30	30	108
Lincoln (P_1) / Bountiful (P_2)	$\bar{X} \pm S_{\bar{X}}$	66.13 ± 6.48	19.90 ± 1.40	58.53 ± 4.62	34.47 ± 3.37	64.03 ± 3.63
	C.V. %	53.74	38.44	43.24	53.64	61.14
	S^2	1263.08	58.51	640.67	341.91	1532.84
No. of observed plants		30	30	30	30	116
Victory Freezer (P_1) / Bountiful (P_2)	$\bar{X} \pm S_{\bar{X}}$	49.03 ± 3.81	19.90 ± 1.39	39.53 ± 3.11	92.73 ± 5.82	62.86 ± 3.00
	C.V. %	42.55	38.44	43.16	34.43	47.02
	S^2	435.27	58.51	291.13	1019.10	873.82
No. of observed plants		30	30	30	30	97

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دراسات وراثية لتحسين الإنتاجية فى البسلة

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تم دراسة السلوك الوراثى لصفات طول النبات ،الأزهار المبكر و عدد القرون الجافة/النبات، وزن القرن الجاف ، وعدد بذور القرن الجاف ، وزن بذور القرن الجاف ، متوسط وزن البذرة ومحصول البذور الجافة/النبات فى تهجين خمسة أصناف من البسلة وتهجيناتها العكسية خلال الفترة من ٢٠٠٠-٢٠٠٢ بمحطة بحوث البساتين بسدس – محافظة بنى سويف – مصر. التهجينات لهذة الدراسة الوراثية هى:–

١– ماستر بى x Pss10699	٢– لنكولن x Pss10699
٣– فيكتورى فريزر x Pss10699	٤– ماستر بى x Bountiful
٥– لنكولن x Bountiful	٦– فيكتورى فريزر x Bountiful

كانت النتائج المتحصل عليها كالآتى:

أظهرت تقديرات فعل الجين الهندسى والحسابى وجود كلا من الفعل الاضافى وغير الاضافى للجينات وانها تلعب دورا هاما فى وراثة هذة الصفات السابقة. أظهرت قياسات درجة السيادة وجود سيادة فائقة فى صفة الازهار المبكر و صفة عدد القرون العالى/ النبات ، ومتوسط وزن البذرة العالى، وصفة المحصول العالى للبذرة الجافة /النبات سيادة فائقة فى بعض أو معظم التهجينات . أما السيادة الجزئية فقد ظهرت تجاة طول النبات ، وصفة وزن القرن العالى ، وصفة وزن بذور القرن العالى وصفة عدد بذور القرن الأقل فى معظم التهجينات. قدرت درجة التوريث على النطاق العريض وكانت عالية لصفات طول النبات وصفة عدد بذورالقرن الجاف فى التهجين ماستر بى x Pss10699. أيضا كانت عالية لصفة الأزهار المبكر فى كل التهجينات لهذة الصفة ماعدا فى التهجين ماستر بى x Bountiful ، وصفة عدد القرون/النبات فى التهجين ماستر بى x Bountiful ، وصفة وزن القرن الجاف فى كل التهجينات لهذة الصفة ماعدا فى التهجينات ماستر بى x Bountiful ولنكولن x Bountiful، وكذلك كانت عالية لصفة محصول البذور الجافة/ النبات فى التهجينات ماستر بى x Pss10699 و ماستر بى x Bountiful وفيكيورى فريزر x Bountiful . عموما فان درجة التوريث العالية فى معظم الصفات التى درست تدل على أنة يمكن استخدام الإنتخاب لتحسين هذة الصفات فى البسلة. وبصفة عامة يوضح التحليل الوراثى ان هناك كمية من الإختلافات الوراثية الميسرة والمتاحة لمربى النبات يمكن استخدامها فى هذه الهجن لتربية وتحسين محصول البسلة.