GENETIC ANALYSIS OF SOME ECONOMIC CHARACTERS IN PEA

ENTSAR M. E. ABO-HAMDA

Veget., Medicinal and Aromatic Plants Breed. Res. Dept., Hort. Res. Inst., Agri. Res. Center, Giza, Egypt.

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Abstract

These experiments were carried out at Kaha Vegetable Research Farm, Qalubia Governorate, Horticulture Research Institute during the period from 2013 to 2016 to study the inheritance of some garden pea (Pisum sativum L.) economic characters, viz., plant length, number of days to flowering, green pod yield/plant, number of pods/plant, number of seeds/pod and shelling percentage. Four garden pea crosses, viz., Master × PS 210713, Master × Sugar gem, Victory freezer × Sugar gem and Victory freezer × 6-Lebanon and their reciprocals were produced. Then, parents, F₁, F₁r, and F₂ populations of each of the four crosses were cultivated on mid October, 2015 in a randomized complete block design (RCBD). The aim of this study was to determine genetic analysis of some economic traits in garden pea. Knowledge about genetics of particular traits is helpful to plant breeder before planning a successful breeding program. Obtained results show that maternal effect was not observed in any cross for all studied traits. Over-dominance or complete dominance was detected for high shelling percentage trait in all studied crosses. High plant length, earliness, high yielding, high no. of pods/plant and high no. of seeds/pod were dominant in some studied populations and contrary were found in others. Positive heterosis over better parent (based on early flowering parent) was noted in all studied populations for earliness and shelling percentage traits, however, negative heterosis was found in all studied populations for other traits. Minimum number of genes (MNG) was 1-5 for plant length, 1-3 for number of days to flowering, 3-4 for green pod yield/plant, 4-10 for number of pods/plant, 1-4 for number of seeds/pod and one gene for shelling percentage. Broad sense heritability (BSH) estimates were 45.52-82.47% for plant length, 65.18-90.11% for number of days to flowering, 77.12-96.10% for green pod yield/plant, 60.60-88.86% for number of pods/plant, 68.20-80.95% for number of seeds/pod and 72.21-74.91% for shelling percentage. The previous results indicate that all studied traits except no. of pods/plant are controlled by one to few numbers of genes and had moderate to high heritability, so the selection for these traits can be preferred in the early generations.

Key words: Pisum sativum, Dominance, Heterosis, Number of genes, Heritability.

INTRODUCTION

Garden pea (Pisum sativum L.) is an important vegetable crop in Egypt due to its high nutritive value. The total cultivated area grown with garden pea in 2015/2016 was 41819 feddan produced 183282 tons with an average of 4.383 tons/fed. (Malr, 2018). Garden pea initial domestication lies in the Mediterranean, primarily in the Middle East. The most important aims for pea breeding are developing high yielding
cultivars with stable productivity. Its improvement is mainly based on exploiting natural germplasm sources by selection or hybridization followed by selection. Heritability is the portion of phenotypic variation which is transmitted from parent to progeny. Highly heritable variation leads to great possibility of fixing character by selection methods (Sharma and Bora, 2013).

Noser (2002), Hamed (2005) and Hamed et al (2015) indicated that maternal effect was not observed for plant length trait in any one of studied crosses. This could be due to nature of self pollination in pea. High positive PR values indicated over dominance and complete dominance towards the tallest parent were estimated for plant length trait (Hamed et al, 2015), meanwhile, El-Dakkak (2016) found partial dominance towards the tallest parent for this trait. Hamed (2005) found negative heterosis in some crosses and positive heterosis in others for plant length trait, meanwhile, El-Dakkak (2016) found negative heterosis (-16.82%) based on the tallest parent for this trait. However, Hamed et al (2015) found positive heterosis over better parent in all crosses for plant length in pea. Minimum number of genes (MNG) for plant length character was 1-3 pairs of genes (Hamed, 2005), 1-5 genes (Noser, 2002) and one gene (Hamed et al, 2015). Broad sense heritability (BSH) of plant length trait was high (Kumari et al, 2009 and Galal, 2014) which suggested that this trait would respond to selection. Meanwhile, Hamed (2005), Hamed et al (2015), El-Dakkak (2016) and Georgieva et al (2016) estimated BSH and it was from 54.6% to 74.2%, from 79.49% to 89.65%, from 85.92% to 98.38%, and 55%, respectively.

Khalil et al (2015) found that maternal effect did not affect inheritance of number of days to flowering character in all studied populations. Meanwhile, Nosser (2002) found that maternal effect was existed for this trait only in one out of the six studied crosses of pea. Also, Hamed (2005) indicated that maternal effect was found only in one out of three studied crosses of garden peas. Positive PR values were calculated indicating partial dominance to late flowering parent as detected in pea populations by Hamed (2005), Abbas (2012) and Khalil et al (2015). Meanwhile, different types of dominance were obtained by Nosser (2002). Also, Sood and Kalia (2006) found complete and over dominance for this trait. Significant positive heterosis based on early parent was observed in all garden pea crosses for days to flowering trait (Hamed, 2005 and Khalil et al, 2015). While, Nosser (2002) found negative heterosis in some crosses and positive heterosis values in the others. Minimum number of genes controlling number of days to flowering trait was estimated as a single gene (Khalil et al, 2015), one to two pairs of genes (Nosser, 2002) and two to seven pairs of genes (Hamed, 2005). High BSH estimates were obtained by Kumari et al (2009), meanwhile, it was ranged from low to moderate (Abbas, 2012). It was
estimated as 65.64% to 94.23% (Noser, 2002), 63.4% to 77.5% (Hamed, 2005), 70.88% to 91.03% (El-Dakkak et al., 2014), 98.0% (Galal, 2014), 93.47% to 94.74% (Khalil et al., 2015) and 90.37% to 98.52% (El-Dakkak, 2016).

No significant differences were stated between F₁'s and their reciprocals for green pod yield/plant trait in all populations indicating no maternal effect (Hamed et al., 2015 and Kosev, 2015). However, Noser (2002) indicated that maternal effect was remarked for green pod yield/plant trait only in 2 out of 6 crosses of garden peas. Overdominance was detected for high green yield/plant trait (Hamed et al., 2015), meanwhile, high positive PR values indicated over dominance and partial dominance towards high yielding parent were estimated by Sood and Kalia (2006). While, Noser (2002) found different types of dominance for this trait. Noser (2002) observed significant positive heterosis of pod green yield/plant in all studied crosses estimated as 6.54% to 74.93% except in one cross which exhibited negative heterosis. Also, positive heterosis (118.29 % and 160.48%) over better parent was found in two populations for green yield/plant trait (Hamed et al., 2015), meanwhile, Kosev (2015) found significant positive heterosis in all studied populations. Minimum number of genes controlling green pod yield/plant was a pair of genes in all populations (Noser, 2002), meanwhile, Hamed et al. (2015) estimated it as 2-3 pairs of genes. High BSH estimates were observed for green pod yield character (El-Dakkak et al., 2014 and Kosev, 2015) indicating good scope of selection for this trait. Also, heritability was estimated as 46.04% to 92.22% (El-Dakkak et al., 2014), 49.44% to 90.81% (Hamed et al., 2015) and 83.33% to 95.17% (El-Dakkak, 2016).

No significant differences were noticed between F₁'s and their reciprocals for number of pods/plant character in all populations indicating absence of maternal effect (Noser, 2002, Hamed et al., 2015 and Kosev, 2015), meanwhile, Hamed (2005) found that maternal effect was existed for this trait only in one out of four studied crosses of pea. High positive potence ratios indicating over dominance towards high parent were observed in all studied populations for number of pods per plant (Sood and Kalia, 2006 and Hamed et al., 2015). Also, Noser (2002) found over dominance of highest parent in three crosses and complete dominance of highest parent in three others. However, Hamed (2005) observed complete dominance of highest parent in 3 out of 4 crosses and complete dominance of lowest number of pods/plant in one cross. Positive heterosis over better parent for number of pods/plant trait was noted in all studied crosses (Noser, 2002 and Hamed et al., 2015). On the other hand, Hamed (2005) estimated negative heterosis values ranged from -32.7% to -2.9% in all evaluated populations. While, Kosev (2015) found positive heterosis in some populations and negative heterosis in others. The different results might be due to
using various germplasm or different environmental conditions. Minimum number of genes controlling number of pods/plant was a pair of genes in all populations (Noser, 2002). Meanwhile, Hamed (2005) and Hamed et al. (2015) estimated it as 1-7 and 3-6 pair of genes, respectively. Kumari et al. (2009) and Kosev (2015) estimated high values of heritability in the broad sense indicating good scope of selection for number of pods/plant trait. In the same direction, Galal (2014) estimated BSH as 90.0% - 91.5%. While, it ranged from 54.9% to 86.0%, from 37.9% to 78.8%, from 32.12% to 86.61%, from 77.30% to 79.91% and from 82.80% to 94.43% as estimated by Noser (2002), Hamed (2005), El-Dakkak et al. (2014), Hamed et al. (2015) and El-Dakkak (2016), respectively, however, Georgieva et al. (2016) estimated it as 39%.

Maternal effect was existed for number of seeds/pod trait only in one out of six crosses as found by Noser (2002), meanwhile, Hamed (2005) and Khalil et al. (2015) indicated that no maternal effect for this trait was found. This could be due to nature of self pollination in pea. Partial dominance towards high parent for number of seeds/pod trait was observed by Hamed (2005), while, Noser (2002) found different types of dominance, viz., over, complete and partial dominance towards the high parent and complete dominance towards the lowest parent for this trait. Also, Sood and Kalia (2006) observed partial and over dominance for this character. Meanwhile, Khalil et al. (2015) found complete dominance towards high parent in one population, however, absence of dominance was obtained in other one. Noser (2002) and Khalil et al. (2015) found positive heterosis over the better parent for number of seeds/pod trait in some garden pea crosses, however, negative heterosis was exhibited in other studied crosses. Meanwhile, Hamed (2005) exhibited low negative heterosis values for this character. Hamed (2005) and Khalil et al. (2015) estimated MNG controlling number of seeds/pod character as one pair. Meanwhile, Noser (2002) found that MNG controlling this trait was 1-7 pairs of genes. Broad sense heritability (BSH) was estimated as moderate to high (Hamed, 2005 and El-Dakkak et al., 2014) and high (Galal, 2014). However, Noser (2002), El-Dakkak et al. (2014), Khalil et al. (2015) and El-Dakkak (2016), found that BSH for this trait ranged from 14.67% to 43.47%, from 57.08% to 84.40%, from 29.22% to 59.78% and from 43.45% to 54.35%, respectively.

Noser (2002), Hamed (2005) and Khalil et al. (2015) found that maternal effect for shelling percentage trait was not observed in any one of the studied crosses. Noser (2002) found complete dominance of better parent in all crosses for shelling percentage trait, meanwhile, Sood and Kalia (2006) and Abbas (2012) found that shelling percentage was controlled by over dominance. Also, positive potence ratios were found indicated over and complete dominance of best parent (Hamed,
2005, and Khalil et al. (2015). Noser (2002), Hamed (2005) and Khalil et al. (2015) estimated positive heterosis, based on better parent, for shelling percentage trait in some studied crosses, while, negative heterosis were obtained in others. Minimum number of genes governing shelling percentage was one pair in all crosses studied by Noser (2002) and Khalil et al. (2015). However, it was estimated as one to three pairs of genes (Hamed, 2005 and Abbas, 2012). Broad sense heritability estimated for shelling percentage trait was low to moderate (Noser, 2002 and Hamed, 2005), meanwhile, Kumari et al. (2009) and Khalil et al. (2015) indicated that it was moderate. Lack of sufficient genetic variability for economically important characters of pea is the reason of doing efforts to progress in crop improvement. So, the research work in this study aims to studying inheritance of some economic traits of garden pea such as plant length, number of days to flowering, green pod yield/plant and shelling percentage which may help to select proper genotypes for future breeding programs.

**MATERIALS AND METHODS**

This investigation was carried out during the period from 2013 to 2016. Production and evaluation of genetic populations were conducted in the open field of Kaha Vegetable Research Farm, Qalubia Governorate, Hort. Res. Institute, Agric. Res. Center, Egypt. Five garden pea cvs., viz., Master, PS 210713, Sugar gem, Victory freezer and 6-Lebanon were selected for genetic studies based on their yield performance and other desired economic traits, viz., plant length, number of days to flowering, shelling percentage and green pod yield/plant. Seeds of these cultivars were cultivated in the open field at Kaha on mid October, 2013. Four crosses, viz., Master × PS 210713, Master × Sugar gem, Victory freezer × Sugar gem and Victory freezer × 6-Lebanon and their reciprocals were produced. Seeds of the F₁ crosses were planted on mid October, 2014. Plant’s flowers were left for selfing to produce F₂ seeds. In the same period, F₁ seeds production was completed.

Genetic population’s evaluation was conducted at Kaha Vegetable Res. Farm. Seeds of parental, F₁, F₁r and F₂ populations of each of the four crosses were planted in a randomized complete block design with three replicates on mid October, 2015. Each replicate contained single row for each non segregating population, i.e., parents, F₁ and their reciprocals and three rows for each F₂. Each row was 3.0 m long and 0.7 m wide. Seeds were planed 15 cm apart individually. Agricultural practices like fertilization, irrigation and pest control were managed as commonly followed in this region.

Data were registered for all populations in each cross on individual plants for plant length, number of days to flowering, green pod yield/plant, number of pods/plant, number of seeds/pod and shelling percentage. Traits were only
investigated in the crosses which their parents were significantly differed in such characters.

Data were recorded as follow:

Plant length was measured at the end of harvesting season from the surface of soil until highest point of stem in cm. Number of days to flowering was measured as number of days from planting to first flower anthesis. Green pod yield/plant was estimated as weight of all harvested pods. Number of seeds/pod was measured as mean number of seeds per five pods/plant. Shelling percentage was calculated for five pods/plant as follows:

Shelling percentage = \( \frac{\text{Seeds weight}}{\text{Total pod weight}} \times 100 \).

**Genetic parameters calculated**

Maternal effect was calculated by measuring significance of difference between every F1 mean and its reciprocal by (t) test. Potence ratio, *i.e.*, relative potency of gene set (PR) was applied to determine direction of dominance according to the formula of Smith (1952). Heterosis was estimated based on better parent using the formula of Sinha and Khanna (1975). Minimum number of genes governing character in each cross was calculated using Wright formula (Burton, 1951). Broad senses heritability (BSH) was calculated using the equation as described by Allard (1960).

**RESULTS AND DISCUSSION**

**1-Plant length**

Regarding plant length trait, data of parental, F1, F1r and F2 populations of the crosses Master × PS 210713, Master × Sugar gem, Victory freezer × Sugar gem and Victory freezer × 6-Lebanon are given in Table 1.

In four studied crosses, parents were clearly different in plant length. Means of F1’s and F2’s were intermediate between their respective parents in all crosses. F2 plants of each cross were widely spreaded between its two parents with transgressive segregations over highest parent in the crosses Master × Sugar gem and Victory freezer × Sugar gem.
Table 1. Distribution, mean and variance of plant length (cm) of parental, F₁, F₁r and F₂ populations of some garden pea crosses.

| Population                      | Frequency of plant length (cm) in class | Total No. of plants | Mean X ± Sx | Variance (δ²) |
|---------------------------------|----------------------------------------|---------------------|-------------|--------------|
| **Master (P₁) × PS 210713 (P₂)**|                                        |                     |             |              |
| P₁                             | 21 9                                   | 30                  | 27.03 ± 1.71 ** | 87.768      |
| P₂                             | 8 11 11                                | 30                  | 123.51 ± 2.95 | 260.517     |
| F₁                             | 4 12 12 1                              | 30                  | 88.00 ± 2.78 NS | 232.190    |
| F₁r                            | 4 14 9 3                               | 30                  | 88.67 ± 3.12  | 292.095     |
| F₂                             | 16 16 32 30 22 2 2                    | 120                 | 67.90 ± 2.58  | 796.703     |
| **Master (P₁) × Sugar gem (P₂)**|                                        |                     |             |              |
| P₁                             | 21 9                                   | 30                  | 27.03 ± 1.71 ** | 87.768      |
| P₂                             | 9 12 9                                 | 30                  | 121.50 ± 2.89 | 250.765     |
| F₁                             | 2 13 10 5                              | 30                  | 113.46 ± 3.14 | 295.345     |
| F₁r                            | 7 7 19 27 26 20 12 2                   | 120                 | 90.68 ± 3.05  | 1119.911    |
| **Victory freezer (P₁) × Sugar gem (P₂)** |                     |                     |             |              |
| P₁                             | 7 17 4 2                               | 30                  | 81.97 ± 2.97 ** | 264.232    |
| P₂                             | 9 12 9                                 | 30                  | 121.50 ± 2.89 | 250.765     |
| F₁                             | 11 4                                  | 30                  | 101.40 ± 3.73 NS | 417.941 |
| F₁r                            | 3 8 10 9                               | 30                  | 98.05 ± 3.62  | 392.401     |
| F₂                             | 7 21 47 29 10 6                        | 120                 | 106.76 ± 2.15 | 554.976     |
| **Victory freezer (P₁) × 6-Lebanon (P₂)** |                     |                     |             |              |
| P₁                             | 7 17 4 2                               | 30                  | 81.97 ± 2.97 ** | 264.232    |
| P₂                             | 1 10 13 6                              | 30                  | 137.58 ± 2.95 | 261.910     |
| F₁                             | 1 8 12 8                               | 30                  | 118.15 ± 3.62 NS | 392.401 |
| F₁r                            | 3 9 9 9                                | 30                  | 115.47 ± 4.43 | 589.297     |
| F₂                             | 4 19 43 19 5 4                         | 120                 | 95.54 ± 2.67  | 855.117     |

* Each class represents a range of 20.1 cm and class values indicated represent class centers.

* Pairs of means were either highly significant (**), significant (*), or not significant (NS) different from each other according to (t) test.

No significant differences were detected between F₁’s and their reciprocals for plant length trait in all crosses indicating no maternal effect. These results typically agree with those of Noser (2002), Hamed (2005) and Hamed et al (2015) and this could be due to nature of self pollination in pea.

Quantitative genetic parameters gained for plant length trait are presented in Table 2.

Several types of dominance were obtained for plant length trait. Positive PR value indicated partial dominance of the high parent in the crosses Master × PS 210713 and Victory freezer × 6-Lebanon and complete dominance of the tallest parent in the cross Master × Sugar gem, however, partial dominance towards the shortest parent were found in the cross Victory freezer × Sugar gem. These various results might be due to using different germplasm. These results are partially agree with those of Hamed et al (2015) and El-Dakkak (2016) who found dominance towards high parent in some population of peas.

All studied crosses exhibited negative high-parent heterosis for plant length trait ranged from -28.75% to -5.51%. These results agree with those of El-Dakkak (2016) who found negative heterosis for this trait and partially agree with those of
Hamed (2005) who found negative heterosis in some crosses and positive heterosis in others for plant length character.

One pair of genes was found to be controlled plant length trait in the cross Master × PS 210713, three pairs of genes in the crosses Master × Sugar gem and Victory freezer × 6-Lebanon and five pairs in the cross Victory freezer × Sugar gem. These different results might be due to using diverse germplasm. These results are in agreement with the previous results which reported that this character was controlled by one pair (Hamed et al., 2015), 1-3 pairs (Hamed, 2005) and 1-5 pairs (Noser, 2002). This means that plant length is quantitatively inherited.

Table 2. Genetic parameters obtained for some characters in some garden pea crosses.

| Character | Plant length | No. of days to flowering | Green pod yield/plant |
|-----------|--------------|--------------------------|-----------------------|
|           | Parameter    | PR | H | MNG | BSH | PR | H | MNG | BSH | PR | H | MNG | BSH |
| M × PS    | PR           | 0.26 | -28.75 | 0.10 | 78.10 | 0.33 | 1.36 | 0.61 | 88.63 | 0.86 | -6.13 | 2.39 | 94.48 |
| M × Sg    | PR           | 0.86 | -5.51 | 2.37 | 82.47 | 0.92 | 7.58 | 2.06 | 90.11 | 0.42 | -25.52 | 2.33 | 96.10 |
| Vf × Sg   | PR           | -0.02 | -16.54 | 4.32 | 45.52 | -0.44 | 3.52 | 0.46 | 65.18 | -0.12 | -34.37 | 2.10 | 84.07 |
| Vf × L    | PR           | 0.30 | -14.12 | 2.04 | 64.85 | 0.71 | 15.04 | 0.55 | 67.67 | 0.10 | -27.50 | 2.38 | 77.12 |

M = Master, PS= PS 210713, Sg = Sugar gem, Vf = Victory freezer, L=6-Lebanon
PR = Potence ratio, H = Heterosis, MNG = Minimum number of genes, BSH = Broad sense heritability.

Calculated BSH for plant length trait were moderate to high being 45.52% to 82.47% (Table 2). These results are in agreement with that of Kumari et al. (2009), Galal (2014), Hamed et al. (2015) and El-Dakkak (2016) who found that it was high. Also, Hamed (2005) and Georgieva et al. (2016) who estimated it as ranged from 54.6% to 74.2%.

2- Number of days to flowering

Data on number of days to flowering trait of parental lines, F1, F1r and F2 populations of the crosses Master × PS 210713, Master × Sugar gem, Victory freezer × Sugar gem and Victory freezer × 6-Lebanon are presented in Table 3.

Parents were highly significant diverse in this character. F1 and F2 means were intermediate between their respective parents in all studied crosses with tendency towards the latest parent except F1 of the cross Victory freezer × Sugar gem and F2 of the cross Victory freezer × 6-Lebanon which tendency towards the earliest parent.
Plants of F\(_2\) were vastly spreaded between their parents with transgressive segregation over the earliest parent in the cross Victory freezer × 6-Lebanon.

On comparing the observed means of the studied F\(_1\)'s and its reciprocals, no significant differences were noticed between F\(_1\) and it's F\(_1\)r in number of days to flowering trait in all the studied crosses indicating absence of mother effect for this character. These results are typically in agreement with Khalil et al (2015) who indicated that maternal effects were absent in all studied crosses for number of days to flowering character. Also, these results are partially agree with findings of Noser (2002) and Hamed (2005) who found that maternal effect was existed only in one cross.

Quantitative genetic parameters obtained for number of days to flowering trait are presented in Table 2.

### Table 3. Distribution, mean and variance of number of days to flowering of parental, F\(_1\), F\(_1\)r and F\(_2\) populations of some garden pea crosses.

| Population | Frequency of number of days to flowering in class\(^a\) | Total No. of plants | Mean \(\bar{X} \pm S_X\) | Variance \((\delta^2)\) |
|------------|-------------------------------------------------------|---------------------|--------------------------|-----------------|
| Master (P\(_1\)) × PS 210713 (P\(_2\)) | 40 47 54 61 68 75 82 89 | 30 | 45.13 ± 0.57 \(**\) | 9.913 |
| P\(_1\) | 8 22 | 30 | 45.13 ± 0.57 \(**\) | 9.913 |
| P\(_2\) | 8 16 6 | 30 | 67.53 ± 0.88 | 23.430 |
| F\(_1\) | 20 8 2 | 30 | 63.80 ± 0.79 \(NS\) | 18.924 |
| F\(_1\)r | 2 17 6 5 | 30 | 64.27 ± 1.10 | 36.271 |
| F\(_2\) | 9 11 11 21 29 29 9 1 | 120 | 64.38 ± 1.10 | 144.104 |
| Master (P\(_1\)) × Sugar gem (P\(_2\)) | 40 47 54 61 68 75 82 89 | 30 | 45.13 ± 0.57 \(**\) | 9.913 |
| P\(_1\) | 8 22 | 30 | 82.00 ± 0.67 | 13.517 |
| P\(_2\) | 4 22 4 | 30 | 80.60 ± 0.78 \(NS\) | 18.294 |
| F\(_1\) | 9 18 3 | 30 | 82.23 ± 0.92 | 25.289 |
| F\(_1\)r | 2 1 21 6 | 30 | 82.23 ± 0.92 | 25.289 |
| F\(_2\) | 16 10 23 23 30 13 5 | 120 | 66.83 ± 1.07 | 136.157 |
| Victory freezer (P\(_1\)) × Sugar gem (P\(_2\)) | 40 47 54 61 68 75 82 89 | 30 | 72.90 ± 0.83 \(**\) | 20.783 |
| P\(_1\) | 12 15 3 | 30 | 72.90 ± 0.83 \(**\) | 20.783 |
| P\(_2\) | 4 22 4 | 30 | 82.00 ± 0.67 | 13.517 |
| F\(_1\) | 28 2 | 30 | 75.47 ± 0.32 \(NS\) | 3.154 |
| F\(_1\)r | 1 26 3 | 30 | 75.47 ± 0.47 | 6.533 |
| F\(_2\) | 8 66 35 11 | 120 | 77.86 ± .048 | 27.585 |
| Victory freezer (P\(_1\)) × 6-Lebanon (P\(_2\)) | 40 47 54 61 68 75 82 89 | 30 | 72.90 ± 0.83 \(**\) | 20.783 |
| P\(_1\) | 12 15 3 | 30 | 72.90 ± 0.83 \(**\) | 20.783 |
| P\(_2\) | 4 6 20 | 30 | 85.73 ± 0.93 | 26.133 |
| F\(_1\) | 1 20 9 | 30 | 83.87 ± 0.67 \(NS\) | 13.292 |
| F\(_1\)r | 1 1 21 7 | 30 | 82.93 ± 0.80 | 19.375 |
| F\(_2\) | 11 23 43 31 12 | 120 | 75.58 ± 0.71 | 59.775 |

\(^a\) Each class represents a range of 7.0 days and class values indicated represent class centers.

\(^\gamma\) Pairs of means were either highly significant \((**)\), significant \((*)\), or not significant \((NS)\) different from each other according to \(t\) test.

Several types of dominance were obtained for number of days to flowering character. Positive PR values (0.92 and 0.71) were calculated indicating complete
dominance of the late parent in the crosses Master × Sugar gem and Victory freezer × 6-Lebanon. Meanwhile, the mean of the cross Master × PS 210713 lied between those of MP and late parent, indicating partial dominance for the late parent. However, negative PR value (-0.44) was estimated indicating partial dominance for the early parent in the cross Victory freezer × Sugar gem. These results partially confirm previous reports of Noser (2002), Hamed (2005), Sood and Kalia (2006), Abbas (2012) and Khalil et al (2015) who observed different types of dominance for this trait. These various results might be due to using different germplasm in each study.

Positive average degrees of heterosis based on early parent were estimated in all studied crosses for number of days to flowering trait ranging from 3.52% to 78.58% (Table 2). These results agree with the findings of Hamed (2005) and Khalil et al (2015) who found positive heterosis in all studied crosses, meanwhile, Noser (2002) found negative heterosis in some crosses and positive heterosis values in the others for this character.

Minimum number of genes governing number of days to flowering trait was calculated as a pair of genes in all studied crosses except in the cross Master × Sugar gem which controlled by three pairs of genes (Table 2). These results are partially in agreement with those of Noser (2002), Hamed (2005) and Khalil et al (2015).

Estimates of BSH for number of days to flowering trait (Table 2) ranged from 65.18% to 90.11% indicating high heritability estimates for this trait. These results indicated the importance of genetic effect in controlling inheritance of this character. These results partially agree with the previous results which indicated that it was high (Noser, 2002, Hamed, 2005, Kumari et al, 2009, El-Dakkak et al, 2014, Galal, 2014, Khalil et al, 2015 and El-Dakkak, 2016).

3-Green pod yield/plant

Data obtained on green pod yield/plant trait of parental, F₁, F₁r and F₂ populations of the crosses Master × PS 210713, Master × Sugar gem, Victory freezer × Sugar gem and Victory freezer × 6-Lebanon are presented in Table 4.

Parents were highly significant various in this character. Means of F₁ and F₂ were intermediate between their respective parents in all studied crosses except F₂ of the cross Victory freezer × 6-Lebanon which was less than the low yielding parent. F₂ plants were greatly spreaded between their parents with transgressive segregation over the high yielding parent in the cross Master × PS 210713.

Non significant differences were noticed between F₁'s and their F₁r's for this character in all crosses indicating no maternal effect. Previous results typically agree
with the findings of Hamed et al. (2015) and Kosev (2015) who indicated that maternal effects were absent for this character.

Genetic parameters obtained for green pod yield/plant are presented in Table 2. Several types of dominance were noticed for this character. Positive PR value (0.86) were calculated indicating complete dominance towards highest yielding parent in the cross Master × PS 210713. Partial dominance to high yielding parent showed for the crosses Master × Sugar gem and Victory freezer × 6-Lebanon. However, negative PR value (-0.12) was calculated indicating partial dominance to lowest parent in the cross Victory freezer × Sugar gem. These results agree with previous results of Noser (2002) who noticed different types of dominance for this trait. These different results might be due to using various germplasm.

### Table 4. Distribution, mean and variance of green pod yield/plant of parental, F₁, F₁r and F₂ populations of some garden pea crosses.

| Population | Frequency of total green pod yield/plant (g) in class | Mean Y ± Sx | Variance (δ²) |
|------------|------------------------------------------------------|-------------|--------------|
| Master (P₁) × PS 210713 (P₂) | 35.0 | 36.00 ± 1.00 ** | 30.200 |
| 65.1 | | | |
| 95.2 | | | |
| 125.3 | | | |
| 155.4 | | | |
| 185.5 | | | |
| 215.6 | | | |
| 245.7 | | | |
| 275.8 | | | |
| 305.9 | | | |
| 336.0 | | | |
| 366.1 | | | |
| P₁ | 29 1 | 30 | 30.200 |
| P₂ | 4 10 12 4 | | |
| F₁ | 2 3 4 11 6 2 2 | | |
| F₁r | 5 4 7 9 4 1 | | |
| F₂ | 23 20 17 18 14 8 4 7 4 3 2 | | |
| Master (P₁) × Sugar gem (P₂) | 20 | 36.00 ± 1.00 ** | 30.407 |
| 30 | | | |
| 40 | | | |
| 50 | | | |
| 60 | | | |
| 70 | | | |
| 80 | | | |
| 90 | | | |
| 100 | | | |
| P₁ | 29 1 | 30 | 30.407 |
| P₂ | 5 15 15 1 | | |
| F₁ | 6 8 4 4 4 4 | | |
| F₁r | 2 9 6 6 7 | | |
| F₂ | 26 13 10 11 10 8 8 7 6 5 2 | | |
| Victory freezer (P₁) × Sugar gem (P₂) | 30 | 113.26 ± 7.01 ** | 1474.609 |
| 40 | | | |
| 50 | | | |
| 60 | | | |
| 70 | | | |
| 80 | | | |
| 90 | | | |
| 100 | | | |
| P₁ | 6 11 5 5 3 | 30 | 113.26 ± 7.01 ** |
| P₂ | 5 6 15 1 1 | | |
| F₁ | 2 9 7 5 5 2 | | |
| F₁r | 2 8 6 6 7 | | |
| F₂ | 20 30 16 15 2 6 4 6 13 6 2 | | |
| Victory freezer (P₁) × 6-Lebanon (P₂) | 30 | 113.26 ± 7.01 ** | 1474.609 |
| 40 | | | |
| 50 | | | |
| 60 | | | |
| 70 | | | |
| 80 | | | |
| 90 | | | |
| 100 | | | |
| P₁ | 6 11 5 5 3 | 30 | 113.26 ± 7.01 ** |
| P₂ | 1 15 11 1 | | |
| F₁ | 1 12 9 6 2 | | |
| F₁r | 10 9 5 1 3 | | |
| F₂ | 39 16 25 20 9 5 1 1 1 2 1 1 | | |

* Each class represents a mean pod weight of 30.1 g and class values indicated represent class centers.
* Pairs of means were either highly significant ( ** ), significant ( * ), or not significant ( NS ) different from each other according to (t) test.

Negative high-parent heterosis values were estimated for all studied crosses ranged from -34.37% to -6.13% for green pod yield trait. These results disagree with
those obtained by Nosr (2002), Hamed et al. (2015) and Kosev (2015). These various results might be due to using various germplasm or planting under several environmental conditions for the different studies.

Minimum number of genes controlling green pod yield/plant trait (Table 2) was estimated as 3 pairs in the crosses Master × PS 210713, Master × Sugar gem and Victory freezer × Sugar gem and 4 genes in the cross Victory freezer × 6-Lebanon indicating polygenic effect of green pod yield character. These results agree with previous results of Hamed et al. (2015) who estimated it as 2-3 pairs of genes.

Estimates BSH for this character ranged from 77.12% to 96.10% indicating low environmental effect on this trait. These results were in agreement with those estimated by El-Dakkak et al. (2014), Hamed et al. (2015), Kosev (2015) and El-Dakkak (2016) who estimated high heritability for green pod yield trait.

4- Number of pods / plant

Concerning number of pods / plant trait, data of parental, F1, F1r and F2 populations of the crosses Master × PS 210713, Master × Sugar gem, Victory freezer × Sugar gem and Victory freezer × 6-Lebanon are showed in Table 5.

In each studied cross, parents were clearly various in number of pods / plant. Means of F1’s and F2’s were intermediate between their parents in all studied crosses with tendency of F2’s towards the lowest parent. In each cross, F2 plants were greatly spreaded between its two parents with transgressive segregation over highest parent in the cross Master × PS 210713.

No significant differences were noticed between F1’s and their F1r’s for this character in all obtained crosses indicating absence of mother effect. Previous results typically agree with those of Nosr (2002), Hamed et al. (2015) and Kosev (2015) who reported that maternal effect was not observed in any one of the studied crosses for this trait. This could be due to nature of self pollination in peas.

Quantitative genetic parameters obtained for number of pods / plant are presented in Table 2.

Partial dominance towards low parent was found in all studied crosses for number of pods / plant trait. These results disagree with the results of Nosr (2002), Hamed (2005), Sood and Kalia (2006) and Hamed et al. (2015) who found dominance of the highest parent in all studied crosses. These diverse results might be due to the various germplasm or unlike environmental conditions in each study.

Data on heterosis (Table 2) showed that the four studied crosses exhibited negative heterosis values ranged from -51.76% to -34.38%. These results typically agree with finding results of Hamed (2005) who estimated negative heterosis values
ranged from -32.7% to -2.9% in all evaluated crosses. However, Kosev (2015) calculated positive heterosis in some studied crosses and negative heterosis in others.

Table 5. Distribution, mean and variance of number of pods/plant of parental, F₁, F₁r and F₂ populations of some garden pea crosses.

| Population                        | Frequency of number of pods/plant in class | Total No. of plants | Mean X ± Sx | Variance (S²) |
|-----------------------------------|-------------------------------------------|---------------------|-------------|---------------|
| Master (P₁) × PS 210713 (P₂)      |                                          |                     |             |               |
| P₁                                | 28 2                                      | 30                  | 9.00 ± 0.69 ** | 14.483        |
| P₂                                |                                          | 30                  | 99.50 ± 1.66  | 83.017        |
| F₁                                | 2 12 12 2 2                              | 30                  | 48.00 ± 2.63 NS | 206.897      |
| F₁r                               | 8 5 5 7 3 2                              | 30                  | 52.00 ± 4.37  | 573.103       |
| F₂                                | 42 36 20 8 9 2 1 1 1                    | 120                 | 28.88 ± 2.17  | 564.564       |
| Master (P₁) × Sugar gem (P₂)      |                                          |                     |             |               |
| P₁                                | 28 2                                      | 30                  | 9.00 ± 0.69 ** | 14.483        |
| P₂                                |                                          | 30                  | 80.00 ± 2.73  | 223.448       |
| F₁                                | 7 17 3 2 1                               | 30                  | 39.5 ± 2.63 NS | 207.155      |
| F₁r                               | 12 9 4 3 2                              | 30                  | 41.00 ± 3.90  | 496.207       |
| F₂                                | 36 23 20 9 5 3 3 3 1                    | 120                 | 26.75 ± 2.20  | 582.298       |
| Victory freezer (P₁) × Sugar gem (P₂) |                                       |                     |             |               |
| P₁                                | 6 11 10 3                                | 30                  | 28.00 ± 2.53 ** | 191.379      |
| P₂                                |                                          | 30                  | 80.00 ± 2.73  | 223.448       |
| F₁                                | 3 6 11 9 1                               | 30                  | 52.50 ± 2.83 NS | 240.259     |
| F₁r                               | 2 10 9 7 2                              | 30                  | 51.50 ± 2.91  | 253.707       |
| F₂                                | 40 28 26 6 16 2 1 1                     | 120                 | 31.13 ± 2.14  | 551.707       |
| Victory freezer (P₁) × 6-Lebanon (P₂) |                                       |                     |             |               |
| P₁                                | 6 11 10 3                                | 30                  | 28.00 ± 2.53 ** | 191.379      |
| P₂                                |                                          | 30                  | 123.00 ± 2.08 | 129.310      |
| F₁                                | 8 9 7 4 2                                | 30                  | 59.50 ± 3.35 NS | 336.466     |
| F₁r                               | 1 6 9 8 4 2                              | 30                  | 61.00 ± 3.86  | 445.862       |
| F₂                                | 31 23 12 6 6 9 8 3 1 1                   | 120                 | 45.25 ± 3.34  | 1342.374     |

Each class represents a range of 15 pods and class values indicated represent class centers.

* Pairs of means were either highly significant ( ** ), significant ( * ), or not significant ( NS ) different from each other according to (t) test.

Minimum number of genes controlling number of pods / plant trait was estimated as four pairs in the cross Victory freezer × Sugar gem, five pairs in the cross Victory freezer × 6-Lebanon, six pairs in the cross Master × Sugar gem and ten pairs in the cross Master × PS 210713. These results are partially in agreement with those found by Hamed (2005) and Hamed et al (2015) who estimated it as 1-7 and 3-6 pairs of genes for this character, respectively.

Broad sense heritability estimated for number of pods / plant was moderate to high and ranged from 60.60% to 88.86% indicating good scope for selection for number of pods/plant trait. These results agree with those obtained by Noser (2002),
Hamed (2005), Kumari et al. (2009), El-Dakkak et al. (2014), Galal (2014), Hamed et al. (2015), Kosev (2015) and El-Dakkak (2016) who estimated high values of heritability in the broad sense for this character.

5- Number of seeds/pod

Data obtained on number of seeds/pod trait of parental, F₁, F₁r and F₂ populations of the crosses Master × PS 210713, Master × Sugar gem and Victory freezer × Sugar gem are presented in Table 6.

In the three studied crosses, parents were highly significant different in this trait. Means of F₁’s and F₂’s were intermediate between their parents in all three studied crosses except the F₂ of the cross Master × PS 210713 which was lower than the low parent. F₂ populations of all crosses were greatly spreaded between its two parents with transgressive segregations over highest parent in the crosses Master × Sugar gem and Victory freezer × Sugar gem.

Table 6. Distribution, mean and variance of number of seeds/pod of parental, F₁, F₁r and F₂ populations of some garden pea crosses.

| Population | Frequency of number of seeds/pod in class | Total No. of plants | Mean X ± Sx | Variance (δ²) |
|------------|------------------------------------------|---------------------|-------------|---------------|
| 2.5 | 3.6 | 4.7 | 5.8 | 6.9 | 8.0 | 9.1 | 10.2 |
| Master (P₁) × PS 210713 (P₂) |
| P₁ | 2 | 4 | 21 | 3 | 30 | 7.82 ± 0.14 ** | 0.591 |
| P₂ | 6 | 9 | 15 | 30 | 5.03 ± 0.16 NS | 0.764 |
| F₁ | 4 | 4 | 15 | 4 | 30 | 5.73 ± 0.22 | 1.497 |
| F₁r | 7 | 4 | 9 | 4 | 6 | 30 | 5.73 ± 0.29 | 2.498 |
| F₂ | 20 | 24 | 25 | 19 | 6 | 1 | 120 | 4.89 ± 0.15 | 2.759 |
| Master (P₁) × Sugar gem (P₂) |
| P₁ | 2 | 4 | 21 | 3 | 30 | 7.82 ± 0.14 ** | 0.591 |
| P₂ | 12 | 14 | 4 | 30 | 4.41 ± 0.14 | 0.579 |
| F₁ | 6 | 12 | 6 | 6 | 30 | 6.24 ± 0.21 | 1.302 |
| F₁r | 5 | 13 | 9 | 3 | 30 | 6.17 ± 0.18 | 0.946 |
| F₂ | 7 | 16 | 18 | 18 | 24 | 21 | 14 | 2 | 120 | 6.21 ± 0.18 | 4.007 |
| Victory freezer (P₁) × Sugar gem (P₂) |
| P₁ | 4 | 13 | 11 | 2 | 30 | 6.20 ± 0.16 ** | 0.791 |
| P₂ | 12 | 14 | 4 | 30 | 4.41 ± 0.14 | 0.579 |
| F₁ | 1 | 8 | 8 | 11 | 3 | 30 | 6.13 ± 0.20 | 1.181 |
| F₁r | 1 | 8 | 9 | 9 | 3 | 30 | 5.98 ± 0.21 | 1.342 |
| F₂ | 12 | 18 | 18 | 44 | 14 | 12 | 2 | 120 | 5.38 ± 0.15 | 2.647 |

* Each class represents a range of 1.1 seeds and class values indicated represent class centers.

Pairs of means were either highly significant (**), significant (*), or not significant (NS) different from each other according to (t) test.

Non-significant differences were showed between F₁’s and their reciprocals for this trait in the three crosses indicating no maternal effect. These results typically agree with those of Hamed (2005) and Khalil et al. (2015) who reported that maternal
effect was not observed in any one of studied crosses. This could be due to nature of self pollination in pea.

Genetic parameters obtained for number of seeds/pod are presented in Table 2.

Several types of dominance were noticed for this trait. Positive PR values (0.92 and 0.08) were estimated indicating complete and partial dominance to highest parent in the crosses Victory freezer × Sugar gem and Master × Sugar gem, respectively. However, negative PR value (-0.50) was calculated indicating partial dominance towards lowest parent in the cross Master × PS 210713. Obtained results agree with previous results of Noser (2002) who found different types of dominance for this trait. These different results might be due to using various germplasm.

All studied crosses exhibited negative heterosis values ranging from -26.74% to -1.18% (Table 2). These results are typically in agreement with results of Hamed (2005) who estimated negative heterosis for this character. Also, Noser (2002) and Khalil et al (2015) found negative heterosis in some crosses.

Minimum number of genes governing number of seeds/pod trait was calculated as a pair in the cross Victory freezer × Sugar gem, two pairs in the cross Master × Sugar gem and four genes in the cross Master × PS 210713. Also, Noser (2002) estimated minimum number of genes governing this trait as 1-7 pairs of genes, meanwhile, Hamed (2005) and Khalil et al (2015) estimated it as a single pair of genes.

Broad sense heritability estimated for number of seeds/pod was high and estimated as 68.20% to 80.95%. These results agree with those obtained by Hamed (2005), El-Dakkak et al (2014) and Galal (2014) who estimated high heritability for this character. However, Noser (2002), Khalil et al (2015) and El-Dakkak (2016) found that BSH for this trait ranged from 14.67% to 43.47%, from 29.22% to 59.78% and from 43.45% to 54.35%, respectively. Previous various results might be due to using another germplasm or various environmental conditions.

6-Shelling percentage:

Data recorded on shelling percentage of parental, F1, F1r and F2 populations of the crosses Master × PS 210713, Master × Sugar gem, Victory freezer × Sugar gem and Victory freezer × 6-Lebanon are presented in Table 7.

Parents in all four crosses were greatly differing in shelling percentage. Means of F1’s were greater than their high parents in all studied crosses. Means of F2’s were intermediate between their respective parents in all studied crosses except the F2 of the cross Victory freezer × Sugar gem which was higher than the high parent. F1 populations of all crosses were widely spreaded between their parents with transgressive segregations over high parents in four studied crosses.
Data showed non-significant differences between F₁’s and their F₁r’s for this character in four studied crosses indicating no mother effect. These results typically agree with previous results obtained by Noser (2002), Hamed (2005) and Khalil et al (2015).

Genetic parameters calculated for shelling percentage are presented in Table 2. Positive PR values (4.30 and 1.51) were estimated indicated over dominance of high parent in the crosses Master × PS 210713 and Master × Sugar gem, respectively. Meanwhile, complete dominance to high parent in the crosses Victory freezer × Sugar gem and Victory freezer × 6-Lebanon were found. These crosses showed insignificant differences with the high parent. These results typically agree with those obtained by Noser (2002), Hamed (2005), Sood and Kalia (2006), Abbas (2012) and Khalil et al (2015) who found that over dominance and complete dominance of best parent were obtained for this trait.

Table 7. Distribution, mean and variance of shelling percentage (%) of parental, F₁, F₁r and F₂ populations of some garden pea crosses.

| Population | Frequency of shelling percentage (%) in class | Total No. of plants | Mean X ± Sx | Variance (δ²) |
|------------|---------------------------------------------|---------------------|-------------|---------------|
| P₁         | 5 17 6 2                                    | 30                  | 50.98 ± 1.03 ** | 31.579        |
| P₂         | 2 12 15 1                                   | 30                  | 46.25 ± 0.88  | 23.467        |
| F₁         | 3 18 7 2                                   | 30                  | 58.79 ± 0.96 NS | 27.581        |
| F₁r        | 1 2 15 9 3                                 | 30                  | 59.50 ± 1.15  | 39.922        |
| F₂         | 20 27 28 24 17 31 1                        | 120                 | 50.04 ± 0.92  | 102.458       |
| P₁         | 5 17 6 2                                    | 30                  | 50.98 ± 1.03 ** | 31.579        |
| P₂         | 2 20 8                                     | 30                  | 37.02 ± 0.71  | 15.297        |
| F₁         | 3 8 15 4                                   | 30                  | 54.53 ± 1.09 NS | 35.924        |
| F₁r        | 1 4 14 9 2                                 | 30                  | 51.46 ± 1.16  | 40.618        |
| F₂         | 7 30 36 21 15 8 3                         | 120                 | 45.24 ± 0.93  | 103.189       |
| P₁         | 1 9 12 7 1                                 | 30                  | 42.23 ± 1.18 ** | 41.487        |
| P₂         | 2 20 8                                     | 30                  | 37.02 ± 0.71  | 15.297        |
| F₁         | 6 19 2 2 1                                 | 30                  | 43.41 ± 1.20 NS | 42.935        |
| F₁r        | 4 18 4 2 2                                 | 30                  | 45.07 ± 1.33  | 53.307        |
| F₂         | 13 37 22 27 11 8 2                         | 120                 | 43.77 ± 0.96  | 110.690       |
| P₁         | 1 9 12 7 1                                 | 30                  | 42.23 ± 1.18 ** | 41.487        |
| P₂         | 3 11 13 3                                 | 30                  | 53.59 ± 1.06  | 33.838        |
| F₁         | 3 4 22 1                                   | 30                  | 54.77 ± 0.91 NS | 24.857        |
| F₁r        | 1 4 5 18 2                                 | 30                  | 53.59 ± 1.21  | 44.268        |
| F₂         | 8 28 42 17 12 7 5 1                         | 120                 | 45.24 ± 0.99  | 117.592       |

* Each class represents a range of 7.1% and class values indicated represent class centers.

* * Each class represents a range of 7.1% and class values indicated represent class centers.

** Pairs of means were either highly significant (**), significant (*), or not significant ( NS ) different from each other according to (t) test.
Positive high-parent heterosis values ranging from 2.21% to 15.32% were estimated in all the studied crosses for shelling percentage character. These results partially agree with that noticed by Noser (2002), Hamed (2005) and Khalil et al (2015) who estimated positive heterosis, based on the highest parent, for shelling percentage character in some crosses.

Minimum number of genes governing shelling percentage character was calculated as a single pair of genes in all four studied crosses (Table 2). Similar results were obtained by Noser (2002) and Khalil et al (2015) who estimated it as one pair in all studied crosses. Meanwhile, it was 1 to 3 genes as assessment by Hamed (2005) and Abbas (2012).

Results in Table 2 showed that calculated BSH for shelling percentage character ranging from 72.21% to 74.91%, indicating low environmental influence on this character. These results disagree with those obtained by Noser (2002), Hamed (2005), Kumari et al (2009) and Khalil et al (2015) who noticed that it was low or moderate. These several results could be due to using various germplasm or unlike environmental conditions by different researchers.

**CONCLUSION**

The previous results indicate that all studied traits except no. of pods/plant are controlled by one to few numbers of genes and had moderate to high heritability, so the selection for these traits can be preferred in the early generations.

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التحليل الوراثي لبعض الصفات الاقتصادية في البسالة

انصار مصطفى إسماعيل إبراهيم

قسم بحوث تربية الخضر والنباتات الطبية والعطرية - معهد بحوث البساتين - مركز البحوث الزراعية - مصر

أجريت التجربة الخاصة بهذه الدراسة بمزرعة بحوث الخضر بقية محافظات القليوبية التابعة لمعهد بحوث البساتين خلال الفترة من 2013 إلى 2016 وذلك بهدف دراسة وراثة بعض الصفات الاقتصادية في البسالة الحضراء مثل طول النبات ، وعدة الأيام حتى أول زهرة ، ومجموع القرن الأحمر للنبات ، وعدد البترون بالقرن ، ونسبة التصافي. تم تجربة 4 هجين من السلسلة الحضراء هم ماستر × بياس 210713 ، وMASTER × شوجر جيم ، وفيكتوري فريزر × شوجر جيم، وفيكتوري فريزر - 6 لبنان. درست وراثة بعض الصفات الاقتصادية في عشرات كل من الآباء والجيل الأول والجيل الأول العكسي والجبل الثاني لكل الهجين في تجربة زرعت في منتصف أكتوبر 2015 في قطاعات كاملة العشوية. وقد أوضح النتائج عدم وجود تأثير للذكى في كل الصفات المدروسة. وجدت سلسلة فائقة وثمة لصفة نسبة التصافي في كل الهجين المدروسة ، بينما في باقي الصفات وجدت سلسلة للأب الأعلى في الصفة في بعض الهجين بينما وجد العكس في بعض الهجين الآخر. أعطت سلسلة عند الأيام حتى ظهور أول زهرة (مقارنة بـ»اللاب المبكر«) ، ونسبة التصافي مقارنة بالأب الأعلى تفوقا موجبا في جميع الهجين المدروسة ، بينما أظهرت سلسلة طول النبات ، ومجموع القرن الأحمر للنبات ، وعدد البترون بالقرن ، وعدد البترون بالقرن قوة هجين سالبة في كل الهجين المدروسة. وقد أظهرت النتائج المحتملة في الصفات المدروسة بـ 1- 3 لصفة طول النبات ، و1- 3 لصفة عدد الأيام حتى ظهور أول زهرة ، و4- 3 لصفة مجموع القرن الأحمر للنبات ، و4- 3 لصفة عدد البترون بالقرن ، و 1- 4 لصفة عدد البترون بالقرن ، و 1- 4 لصفة عدد البترون بالقرن. ووجد واحد فقط من الجينات لصفة نسبة التصافي. قدرت درجة الترويض على نطاق العرض فكانت 45.52 - 52.47 لصفة طول النبات ، 65.18 - 90% لصفة عدد الأيام حتى ظهور أول زهرة 77.12 - 96.1%. لصفة مجموع القرن الأحمر للنبات 82.47 - 88.86% لصفة عدد البترون بالقرن 74.91 - 80.8% لصفة عدد البترون بالقرن 68.2% - 72.21% لصفة عدد البترون بالقرن. ونسبة التصافي. وتحمل الدراسة أنه من النتائج السابقة يتضح أن جميع الصفات المدروسة ماعدا صفة عدد البترون بالقرن تحكم فيها عدد قليل من الجينات ودرجة ترويضها متوسطة إلى عالية وبالتالي يمكن إجراء الاختبار لهذه الصفات في الأجيال المبكرة.
