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# GENETICAL STUDIES ON SOME IMPORTANT TRAITS IN RAPE SEED (CANOLA)

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## ABSTRACT

This study aimed to investigate the type of gene action and the relative amount of genetic variations as well as their interactions with locations. The study included the eight lines DH1, DH3, DH4, DH5, DH6, DH7, DH8 and DH9. These lines were homozygote. The two testers Serw6 and Serw8 were ued to produce (8 lines X 2 testers) 16 $F_1$ hybrids. All genotypes were evaluated at two different locations. The data were recorded for some traits including: Days to 50 % flowering, plant height in centimeters, number of primary branches per plant, number of silique per plant, Weight of 1000 seeds, Seed yield per plant in grams and Oil percent.

The mean squares of locations, genotypes were highly significant for all studied traits. Also, the genotypes by locations interactions mean squares were highly significant for all traits. These genotypes indicating the presence of real differences between these genotypes for these traits.These genotypes gave also different performances at the different environments. The results showed that the means of $F_1$ hybrids were earlier where they showed less for Days to 50 % flowering, in plant height the hybrids were shorter. Thus, negative but desirable heterosis values over mid-parents and high-parent of (DH5 x Serw8) were observed for days to 50 % flowering, plant height, and weight of 1000 seed traits.

Significant and desirable GCA effect were exhibited for the two parents DH4 and DH5 for Days to 50 % flowering and plant height while it was undesirable for the other studied traits.

Significant and desirable SCA effect were exhibited in the F1 hybrid DH5 x Serw8 for Days to 50 % flowering and plant height while it was undesirable for the other studied traits.

The results revealed that additive effects play a major role in the expression of studied traits, while dominance effects had a minor role for the other trait.

Heritability estimates in broad sense ($h^2_b$ %) ) and narrow sense ($h^2_n$) for all traits were high. Days to 50 % flowering, Plant height, number of primary branches per plant, number of silique per plant, Weight of 1000 seeds, Seed yield per plant in grams and Oil percent were: (92.09, 94.26, 36.01, 0.0, 74.13, 75.59, 9.41) and (57.96, 64.23, 27.35 , 0.0, 44.48, 75.59, 0.0) for broad and narrow sense heritability, respectively.

## INTRODUCTION

Canola seeds contain more than 40 % oil from its weight. Therefore, it is rich in oil content than other oil crops such as: Cotton (25 %), Soya been (20 %), maize (15 %) and it is close to sunflower (40%). The high percentage of oil in canola makes it the leading oil crop in the world. For that reason, it is cultivated in large areas in many countries. The increase of yield in this crop is largely due to the increase of the annual yield production resulting from the utilization of hybrids and the expansion of planting area of this crop.

Different studies have provided definition for either the best or the more convenient tester Thakur and Sagwal (1997) mentioned that heterosis over the better parent for the various canola traits were significant . Thakurand Bhateria (1993) found that sca were larger than the gca estimates for yield and its components. Chaudhary *et al*. (1997) revealed that both additive and non additive gene actions were important in controlling most of the traits studied. Gupta et.al (2006) found that gca and sca components were significant for all traits. Amiri-Oghana *et al*. (2009) indicated that the additive gene effects were more important than non-additive gene effects for all traits studied. Aytac Zehra and Gulcan Kinaci (2009) revealed that additive gene effects are important in the inheritance of these traits. Therefore, this investigation aimed to estimate the genetic variance components and their interactions environments and to obtain estimates for: heterosis, GCA, SCA effects and heritability in broad and narrow sense.

## MATERIALS AND METHODS

The genetic materials included Serw6 and Serw8 which were used as testers and DH1, DH3, DH4, DH5, DH6, DH7, DH8 and DH9 used as lines. They were homozygote double haploid lines obtained from natural haploid plant. This investigation was carried out during the two growing seasons of 2007/2008,

2008/2009. The experiments were executed at The farm of Department of Genetics,Faculty of Agriculture ,Mansoura University and at Abo Elkheir farm at Mahmodia, Dekernes , Dakahlia at northern east of delta, Egypt. The mating design was made according to line x tester. The experimental design used at each location was a randomized complete blocks design with three replications. The data were recorded on five guarded randomly chosen plants per plot for all genotypes in the two environments on: Days to 50 % flowering, Plant height in centimeters, Number of primary branches per plant, Number of silique per plant, Weight of 1000 seeds, Seed yield per plant in grams and Oil percent . The combined analyses were done over the two locations as out lined by Steel and Torrie (1980). The lines x testers analyses were made according to Kempthorne (1957) for each location and for the combined data over the locations.

Several analysises of variances were made in order to test significance of the differences among the ten parents, 16 F1 hybrids at the two locations.

**Statistical analysis:**

The heterosis values were determined as the relative deviation of F1 hybrids mean from their mid-parents and high-parent. The heritability estimates were determined according to the following equations:

1- Heritability in broad sense:

$$h2\ (b.s.)\% = \frac{\sigma^2 A + \sigma^2 D}{\sigma^2 A + \sigma^2 D + \sigma^2 E} X\ 100$$

2- Heritability in narrow sense:

$$h2\ (n.s.)\% = \frac{\sigma^2 A}{\sigma^2 A + \sigma^2 D + \sigma^2 E} \times 100$$

## RESULTS AND DISCUSSION

The combining ability analyses for the studied traits were made for days to 50% flowering, plant height, number of primary branches per plant, number of silique per plant ,Weight of 1000 seeds, Seed yield per plant in grams and Oil percent at their combined data and the mean squares are presented in Table 1. The results of mean squares revealed that locations, genotypes included parental lines and their top crosses were highly significant for all studied traits at the combined data. This finding indicated that these genotypes varied in their behavior with respect to all traits. Parents versus crosses were highly significant indicating to the presence of heterosis for most traits.

The interactions of genotypes, parents and crosses with locations were found to be highly significant of all traits. In the same time, the interactions of parents vs. crosses with locations were highly significant of all traits while it was only significant of days to 50% flowering and insignificant for plant height and number of primary branches per plant at combined data. It could be concluded that the test of potential parents for the expression of heterosis could be necessarily conducting over a number of locations and that genetic diversity would guarantee the expression of heterosis.

Further partition of crosses mean squares to lines, testers and lines by testers were made and the results are shown in Table 1. The results indicated that mean squares of lines were highly significant for all traits studied and from combined data. However, testers were highly significant for all traits except plant height, number of primary branches per plant, and Oil percent.

On the other hand, lines by tesers mean squares were highly significant for all studied traits. These results indicated to the role of non-additive genetic variance in the genetic expression of all these traits. The average means of Lines and testers mean squares as indicator to additive variance was more than the corresponding values of lines X tester mean squares for all studied traits . These findings revealed greater role of additive genetic variances in the genetic expression of these traits. However, the interaction of lines by locations was highly significant for all traits studied. This value was not significant of number of primary branches per plant but highly significant for respect to lines X testers by locations interaction. This finding revealed that non-additive genetic variance was more stable than the corresponding estimates of additive genetic variance in these traits. Similar results were obtained by Patel *et al*. (1996), Satwinder *et al*. (1997), Henryk *et al*. (1999), Halaka (2000), Kassab (2004), El-Azzony (2005), Nassimi *et al*. (2006), *Abd EI-Maksoud et al*.(2008) and Akbar *et al*. (2008).

**Mean performance:**

The mean performances of the parental lines and their hybrid combinations F1 for all studied traits are presented in Table 2.

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In general, the means of the 8 parental lines for all traits showed the superiority of certain parent for these traits. In this respect, the line DH3 appeared to be the earliest (68.5) days , with plant height (179.6) where the line DH5 was the shortest (170.9). The line DH9 had the larger number of primary branches per plant and oil percent 6.6 and 51.1, respectively . The results indicated that the largest number of silique per plant was found in line DH1 (1000), Weight of 1000 seeds was obtained from the line DH7 and it was (4.36). Seed yield per plant in grams, was larger in parental line DH4 64.2.

The hybrid DH5xSerw8 started its flowering branches after (68.1days) and it was lower than the earlier parent and it was also shorter in plant height. The hybrids DH8xSerw6 or DH8 x Serw8 gave high number of primary branches /plant. In the same time, the larger F1 the hybrid DH9x Serw8 gave (1338.8) for number of silique per plant .Weight of 1000 seeds was obtained from the F1 hybrids, DH7xSerw6 of ( 4.17). Regarding the Seed yield per plant in grams, it was obtained from the hybrid combination, DH9x Serw8 of (89.4). Concerning oil percent, it was higher for the hybrid DH6xSerw6 of (50. 3),

Generally, the means showed that most F1 hybrids exceeded their parents, which were involved in the hybridization for most traits. It also appeared that the best F1 hybrid was resulted from crosses involving the best parents. The hybrid DH5xSerw8 (68.1days) started its flowering branches lower than the earlier parents and it was shorter in plant height. Similar results were obtained by Kandil *et al*. (1996), Halaka (2000), Pourdad and Sachan(2003) El-Azzony (2005), Abd El-Maksoud *et al*. (2008) ) and Zesu Huang *et al* (2010).

**Estimates of heterosis :**

Heterosis values were calculated with respect to , mid –parents and high-parent for all studied traits from the combined data are presented in Table 3. The estimates of heterosis from the mid-parents for Days to 50% flowering was found from the hybrid DH5xSerw8. Seven hybrids were earlier than the higher parent. For plant height, heterosis over mid-parents and high-parent were significant for three hybrid combinations. Number of silique per plant and Seed yield per plant were significant higher than the mid-parents and high–parent. For Weight of 1000 seeds and oil percent, the hybrid combinations showed highly significant negative heterosis over mid-parents and high parent. Similar results were obtained by Grant and. Beversdorf (1985), Kassab (2004), El-Azzony (2005), Pietka *et al*. (2005), Naushad *et al*. (2006) and Amiri-Oghana *et al*. (2009).

**General combining ability effects:**

General combining ability effects (gi) for all parental lines for all traits for Days to 50% flowering, Plant height, Number of primary branches per plant, Number of silique per plant ,Weight of 1000 seeds, Seed yield per plant in grams and oil percent were measured and the results are presented in Table 4. The results indicated that, the lines DH4, DH5 and the tester Serw6 showed highly significant negative GCA effect for Days to 50% flowering.

For Plant height Lines DH4, DH5 and DH9 could be considered as good combiner and could develop shorter hybrids. Concerning number of primary branches per plant, DH8 was considered as good combiner for this trait. These findings indicated that the lines and testers were considered as good combiners and could develop earlier and shorter hybrids.

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The lines could be used as good donors for developing hybrid combinations for Number of primary branches per plant. Line DH9 had highly significant positive combiners for number of siliques per plant. The lines: DH6,DH7and DH8 were good combiners for 1000 seed weight at combined data while the lines DH1, DH3,DH6 and DH9 for seed yield per plant showed highly significant positive. Similarly, the two parental line DH3 and DH4 exhibited highly significant positive GCA effects, for oil percent. The results revealed that GCA effects were desirable but negatively significant or highly significant for earliness and shorter hybrids, respectively.

Specific combining ability effects (Sij)

Specific combining ability effects (Sij) were calculated for the 16 F1 hybrids for all traits and the results are given in Table 5.The results indicated that three hybrid combinations showed significant and highly significant negative specific combining ability effects for days to 50% flowering trait from the combined data. These hybrids were DH3xSerw6, DH5xSerw8, and DH8xSerw6. These results indicated that these hybrids should be considered in breeding for early flowering. For Plant height, the results also indicated that the hybrids: DH1xSerw6, DH5xSerw8 and DH8xSerw6 would involve one or two superior parental lines. The results showed the presence of superior hybrid among the best combinations as good specific combiner for plant high. In the same time, hybrids showed insignificant either negative or positive (Sij) from the combined data for number of primary branches per plant and shown in the hyblid DH7xSerw6 (-0.160) which was previously found to express useful heterosis. Also, some of the parental lines which involved in these superior hybrids were detected to be best combiner for number of slique per plant. For weight of 1000 seed the hybrids DH1xSerw8, DH4XSerw6 and DH6XSerw8were the best. One F1 hybrid showed positive and significant sca for seed yield per plant in grams DH6xSerw6 (6.223). For oil percent trait, the best hybrids were DH1x Serw8, DH6 x Serw6, and DH8x Serw8. These hybrids could be used as new hybrids or to be utilized in a breeding program to improve these traits.

These results were in agreement with many authors who obtained similar results among them Patel *et al*. (1996), Varsheny and Rao (1997), Halaka (2000), Hassan and Abdul-Rashid (2003) and Kassab (2004), Nassimi *et al*. (2006), Akbar *et al*(2008), Amiri-Oghan *et al*. (2009)and Zesu Huang *et al*. (2010).

**Genetic parameters:**

Genetic parameters as well as heritability values were estimated for all studied traits and the results are presented in Table 6 for Days to 50% flowering, plant height, Number of primary branches per plant, number of slique per plant, 1000 Seed weight, Seed yield per plant in grams and Oil percent .

The result indicated that the estimates of the additive variance ($\sigma^2A$) indicated the importance of GCA% for all studied traits which were higher than dominance variance ($\sigma^2D$ ) measured from sca. Weight of 1000 seeds in grams and Oil percent indicated that these traits are governed by non additive genetic variance.

Concerning heritability estimates in broad sense ($h^2_b$ %) , the results indicated that the values of heritability were high for all studied traits, Days to 50% flowering, Plant height, and Number of primary branches per plant were 92.09, 94.26and 36.01, respectively.

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However, heritability estimates in the narrow sense for all traits from the combined data were 57.96, 64.23, 27.35, 0.0, 44.48, 75.59 and 0.0 , respectively. These results indicated that a major part of the total genotypic variances were additive in nature and are in general agreement with those reported by many authors who obtained similar results among them Chaudhary *et al* . (1997 ) which exploit both additive and non-additive gene effects, Teilep (2003) ,Hassan and Abdul Rashid (2003) indicated that the additive gene effect were more important than non-additive gene effects in the inheritance at these traits.

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# دراسات وراثية على بعض الصفات الهامة فى الكانولا

**كـــوثر ســـعد قـــش* ، محمـــد ســـعد حمـــاده** ، رحـــاب محمـــد حبيبـــة* و شيماء محمد رفعت احمد على ابو الخير***

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تم تقييم ثمانية سلالات من الكانولا المتضاعفة العدد الكروموسومى الأحادى واثنين كشافان هما سيرو6 وسيرو 8 لإنتاج 16 هجين تم تقيمهما فى موقعين احدهما مزرعة كلية الزراعة بالمنصورة والثانية فى عزبة أبو الخير تابعة للمحمودية- مركز دكرنس- دقهلية.

حيث تم دراسة الصفات التالية تفتح 50%من الأزهار- طول النبات- عدد الفروع الأولية لكل نبات- وزن الألف بذرة وزن محصول البذور لكل نبات- نسبة الزيت.ولقد تم تحليل التباين فى كل موقع ثم الموقعين معا وكانت النتائج كاللأتى :

أظهر التباين للمواقع والتراكيب الوراثية معنوية عالية لجميع الصفات المدروسة وكذلك اظهر تفاعل التراكيب الوراثية فى المواقع معنوية عالية لجميع الصفات وهذا يدل على وجود اختلاف للتراكيب الوراثية فى المواقع المختلفة كما أظهرت النتائج أن الجيل الأول الهجين أكثرتبكيرا وأقصر طولا النبات وأن قوة الهجين تظهر قيمة سالبة عند حسابها من متوسط اللأبوين والأب الأعلى حيث ظهر الهجين DH5xSerw8 تقدير سالب للتزهير وطول النبات.أظهرت القدرة العامة والخاصة على التألف أن السلالات DH5,DH4والهجين DH5xSerw8 كانت مناسبة للتبكير وطول النبات وكانت الصفات الأخرى غير مناسبة.كما أظهرت النتائج أن قيم معامل التوريث فى المدى الواسع أعلى من المدى الضيق مما يدل على أن التباين الوراثى التجميعى أكثر تأثيرا لمعظم الصفات المدروسة.

**قام بتحكيم البحث**

| | |
|---|---|
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**Table1** : **Analysis of variance and mean squares estimates for all studied traits at the combined data over the two locations**

| S.V | D.F. | Days to 50% flowering | Plant height in centimeters | Number of primary branches per plant | Number of clique per plant. | 1000 Seed weight in grams. | Seed yield per plant in grams. | Oil percent |
|---|---|---|---|---|---|---|---|---|
| | Comb. | Comb. | Comb. | comb. | Comb. | Comb. | Comb. | Comb. |
| Locations(L) | 1 | 2625.6** | 15732.3** | 207** | 27013711.5** | 3.6** | 92272.02** | 2862.9** |
| Reps/(L) | 4 | 4.839 | 11.39 | 1.608* | 847. 93 | 0.007 | 26.41 | 2.404 |
| Genotypes (G) | 25 | 569.32** | 1520.9** | 4.728** | 198870. 9** | 0.359** | 111.4** | 34.44** |
| Parent (P) | 9 | 958.41** | 1423.04** | 1.726** | 131901.7** | 0.45 8** | 670.8** | 20.23** |
| Crosses © | 15 | 361.38** | 1465.8** | 2.577** | 126270. 2** | 0.318** | 638. 3** | 43.64** |
| P.Vs.C | 1 | 186.58** | 3228.05** | 64.01** | 1890604** | 0.094** | 12235.4** | 24.27** |
| GxLoc | 25 | 31.45** | 245.19** | 1.417** | 137284. 9** | 0.149** | 1407. 3** | 37.34** |
| PxLoc | 9 | 33.46** | 430.05** | 1.672** | 142326. 9** | 0.134** | 384.7** | 22.14** |
| CxLoc | 15 | 30.39** | 149.75** | 1.355** | 131160.03** | 0.144** | 360. 8** | 43.72** |
| P.Vs.Cx Loc | 1 | 29.22* | 13.06 | 0.055 | 183781.1** | 0.368** | 1247.6** | 78.22** |
| Lines (GCA) | 7 | 614.59** | 2547.24** | 3.571** | 127114. 5** | 0.418** | 964.1** | 34.13** |
| Testers (GCA) | 1 | 110.51** | 22.52 | 0.260 | 36593.7* | 0.552** | 1231.2** | 1.71 |
| LxT(SCA) | 7 | 144.01** | 590.51** | 1.915** | 138236.8** | 0.183** | 227.7** | 59.14** |
| LxLoc | 7 | 59.59** | 180.71** | 0.932 | 77324.4** | 0.19** | 381.3** | 35.41** |
| TxLoc | 1 | 0.5106 | 48.88 | 2.219** | 29319.6* | 0.327** | 858.01** | 32.89** |
| LxTxLoc | 7 | 5.439 | 133.19** | 1.653** | 199544.4** | 0.072** | 269. 3** | 53. 58** |
| Error | 100 | 4.41 | 15.387 | 0.556 | 7168.4 | 0.004 | 29.78 | 3. 29 |

***and **Significant at 5% and 1% levels of probability, respectively.**

**Nots: Loc is location**

**Table 3 : Percentage of heterosis of the F1 hybrids (8x2) over mid-parent (M.P) and high-parent (H.P) for all studied traits at the combined data over the two locations**.

| Hybrids | Days to 50% flowering | | Plant height in centimeters | | Number of primary branches per plant | | Number of silique per plant | | Weight of 1000 seeds in grams | | Seed yield per plant in grams | | Oil percent | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | M.P | H.P | M.P | H.P | M.P | H.P | M.P | H.P | M.P | H.P | M.P | H.P | M.P | H.P |
| **DH1xSerw6** | 2.15 | -8.02** | 10.09** | 3.99* | 19.67* | 14.06 | 37.75** | 21.13** | 0.00 | 3.75** | 65.98** | 56.67** | -7.35** | -7.66 |
| **DH1xSerw8** | 13.35** | -4.34* | 24.38** | 11.97** | 20.00* | 18.18 | 8.25 | 2.50 | 4.44** | 0.00 | 47.90** | 25.80** | 0.97 | -0.64 |
| **DH3xSerw6** | 9.16** | -0.835 | 6.19** | 6.12** | 40.91** | 34.48** | 35.52** | 29.11** | 2.73* | 0.8 | 75.59** | 44.29** | 9.17** | 8.93** |
| **DH3xSerw8** | 28.7** | 25.97** | 13.47** | 7.74** | 14.41 | 3.03 | 44.37** | 25.16** | -2.99* | -5.32** | 61.84** | 22.17** | 5.17 | 4.05 |
| **DH4xSerw6** | 0.399 | -1.01 | 5.09** | 3.65 | 6.25 | 3.45 | -1.36 | 9.98 | 9.47** | 7.22** | 3.28 | -6.77 | 6.15* | 5.69 |
| **DH4xSerw8** | 6.64** | 0.429 | 10.87** | 6.73** | 17.5* | 7.57 | 9.42 | 7.88 | -6.15** | -9.54** | 16.97** | 15.9* | 0.22 | -1.49 |
| **DH5xSerw6** | 4.92* | -2.80 | 7.18** | 4.65* | 37.5** | 32.76** | 53.30** | 41.49** | -4.08** | -8.74** | 13.06 | 9.19 | 6.45* | 8.03*- |
| **DH5xSerw8** | -5.02* | -5.35* | -3.96* | -6.60** | 10.53 | 5 | 12.73 | 3.15 | -8.03** | -13.83** | 15.14** | 6.42 | -2.12 | -2.54 |
| **DH6xSerw6** | -1.68 | -8.56** | 10.33** | 4.98** | 25.22** | 24.14* | 32.50** | 18.76* | 5.12** | 3.09* | 21.62** | 21.39* | 10.67** | 10.06** |
| **DH6xSerw8** | 10.15** | -4.26* | 16.43** | 5.54** | 13.82 | 6.06 | 0.129 | -3.19 | 7.49** | 3.61** | -1.36 | -11.62 | -10.75** | -12.37** |
| **DH7xSerw6** | -0.672 | -6.34** | 4.72** | -1.33 | 15.31 | 10.34 | 23.20** | 11.64 | 3.13** | -4.36** | 35.53** | 15.09 | -0.53 | -3.11 |
| **DH7xSerw8** | 10.23** | -2.96 | 8.55** | -2.51 | 10.92 | 0.00 | 59.23** | 34.52** | 4.02** | -5.04** | 47.30** | 14.22* | -6.41* | -7.68* |
| **DH8xSerw6** | -1.68 | -8.56** | 4.87** | 0.00 | 30.08** | 23.08* | 26.80** | 14.00* | -6.65** | 6.80** | 11.16 | 7.82 | -6.88* | -6.99* |
| **DH8xSerw8** | 15.63** | 0.513 | 20.03** | 9.03** | 22.14** | 21.21* | 25.31** | 21.55** | 7.44** | 4.75** | -4.48 | -12.08 | 0.75 | -0.43 |
| **DH9xSerw6** | 0.895 | -2.40 | -2.68* | -8.2** | 25.81** | 18.18 | 36.54** | 24.06** | 7.83** | 5.36** | 32.29** | 26.45** | -8.26** | -13.11** |
| **DH9xSerw8** | 13.31** | 2.23 | 2.16 | -8.16** | 16.67* | 16.67 | 46.97** | 44.22** | 2.79* | 2.22 | 46.47** | 36.69** | -6.73* | -10.57** |
| **LSD 5%** | 2.955 | 3.412 | 5.519 | 6.373 | 1.049 | 1.210 | 119.1 | 137.6 | 0.085 | 0.099 | 7.679 | 8.867 | 2.55 | 2.95 |
| **1%** | 3.919 | 4.526 | 7.320 | 8.453 | 1.391 | 1.607 | 157.9 | 182.4 | 0.113 | 0.131 | 10.18 | 11.76 | 3.38 | 3.90 |

***and****Significant at 5% and 1% levels of probability, respectively.**

**Table 4** : **Estimates of GCA effects (gi) of lines and testers for all studied traits at the combined over the two locations.**

| Genotypes | Days to 50% flowering | Plant height in centimeters | Number of primary branches per plant | Number of silique per plant | Weight of 1000 seeds in grams | Seed yield per plant in grams | Oil percent |
|---|---|---|---|---|---|---|---|
| | Comb. | Comb. | Comb. | Comb. | Comb. | Comb. | Comb. |
| Lines: | | | | | | | |
| DH1 | 9.885** | 21.56** | 0.35 | 59.72 | -0.175** | 11.86** | -1.43** |
| DH3 | -1.448 | -4.17 | 0.067 | -9.41 | -0.184** | 7.49** | 3.52** |
| DH4 | -5.948** | -10.19** | -0.642* | -148.62** | -0.011 | -1.97 | 1.43** |
| DH5 | -13.53** | -22.60** | -0.225 | -88.98* | -0.194** | -4.66* | -1.08** |
| DH6 | 2.885** | 12.81** | -0.125 | -26.74 | 0.160** | -9.40** | 0.15 |
| DH7 | 1.885* | 2.66 | -0.75* | -33.90 | 0.307** | -2.67 | 0.23 |
| DH8 | 5.219** | 10.38** | 0.80** | 61.16 | 0.141** | -11.38** | -1.21** |
| DH9 | 1.052 | -10.45** | 0.525 | 186.77** | -0.044 | 10.73** | -0.85 |
| S.E (Lines) | 0.857 | 1.60 | 0.304 | 34.565 | 0.025 | 2.228 | 0.74 |
| Testers: | | | | | | | |
| Serw6 | -1.073* | -0.484 | 0.052 | -19.524 | 0.076** | -3.581 | 0.133 |
| Serw8 | 1.073* | 0.484 | -0.052 | 19.524 | -0.076** | 3.581 | -0.133 |
| S.E (Testers) | 0.429 | 0.801 | 0.152 | 17.282 | 0.012 | 1.104 | 0.37 |

***and**Significant at 5% and 1% levels of probability, respectively.**

**Table 5 : Estimates of SCA effects (Sij) of the 16 $F_1$ hybrids for all studied traits at the combined data over the two locations.**

| Hybrids | Days to 50% flowering | Plant height in centimeters | Number of primary branches per plant | Number of silique per plant | Weight of 1000 seeds in grams | Seed yield per plant in grams | Oil percent |
|---|---|---|---|---|---|---|---|
| | Comb. | Comb. | Comb. | Comb. | Comb. | Comb. | Comb. |
| DH1xSerw6 | -0.844 | -7.565** | -0.277 | 112.69* | -0.16** | 2.964 | -2.342* |
| DH1xSerw8 | 0.844 | 7.565** | 0.277 | -112.69* | 0.16** | -2.964 | 2.342* |
| DH3xSerw6 | -2.677* | -0.965 | 0.456 | -49.901 | 0.025 | 0.931 | 0.425 |
| DH3xSerw8 | 2.677* | 0.965 | -0.456 | 49.901 | -0.025 | -0.931 | -0.425 |
| DH4xSerw6 | 1.656 | 0.326 | -0.619 | -62.592 | 0.252** | -4.427 | 0.917 |
| DH4xSerw8 | -1.656 | -0.326 | 0.619 | 62.592 | -0.252** | 4.427 | -0.917 |
| DH5xSerw6 | 7.739** | 14.567** | 0.648 | 123.57* | 0.032 | 0.919 | -1.442 |
| DH5xSerw8 | -7.739** | -14.567** | -0.648 | -123.57* | -0.032 | -0.919 | 1.442 |
| DH6xSerw6 | -1.010 | -0.074 | 0.014 | 124.65* | -0.084* | 6.223* | 4.433** |
| DH6xSerw8 | 1.010 | 0.074 | -0.014 | -124.65* | 0.084* | -6.223* | -4.433** |
| DH7xSerw6 | -0.510 | 1.667 | -0.160 | 158.03** | -0.059 | -3.994 | 0.975 |
| DH7xSerw8 | 0.510 | -1.667 | 0.160 | -158.03** | 0.059 | 3.994 | -0.975 |
| DH8xSerw6 | -3.344** | -8.424** | -0.060 | -16.368 | -0.055 | 4.498 | -2.158* |
| DH8xSerw8 | 3.344** | 8.424** | 0.60 | 16.368 | 0.055 | -4.498 | 2.158* |
| DH9xSerw6 | -1.010 | 0.467 | -0.003 | -74.034 | 0.049 | -5.277 | -0.808 |
| DH9xSerw8 | 1.010 | -0.467 | 0.003 | 74.034 | -0.049 | 5.277 | 0.808 |
| S.E | 1.212 | 2.265 | 0.430 | 48.882 | 0.0351 | 3.124 | 1.05 |

***and**Significant at 5% and 1% levels of probability, respectively.**

**Table 6** : **Estimates of genetic parameters and heritability in broad and narrow senses for all studied traits and oil percent at each location and the combined data over the two locations.**

| Genetic parameters and heritability | Days to 50% flowering | Plant height in centimeters | Number of primary branches per plant | Number of silique per plant | Weight of 1000 seeds in grams | Seed yield per plant in grams | Oil percent |
|---|---|---|---|---|---|---|---|
| | Comb. | Comb. | Comb. | Comb. | Comb. | Comb. | Comb. |
| Additive variance ($\sigma^2A$) | 39.21 | 163.06 | 0.138 | -3044.4 | 0.027 | 82.28 | -3.28 |
| Dominant variance ($\sigma^2D$) | 23.09 | 76.22 | 0.044 | -10217.9 | 0.018 | -6.93 | 0.927 |
| Environmental variance ($\sigma^2E$) | 4.41 | 15.39 | 0.556 | 7168.4 | 0.004 | 29.78 | 3.29 |
| Genotypic variance ($\sigma^2G$) | 62.31 | 239.28 | 0.182 | -13262.3 | 0.045 | 82.28 | 0.927 |
| Phenotypic variance ($\sigma^2P$) | 67.66 | 253.85 | 0.504 | -6263.7 | 0.061 | 108.84 | 8.928 |
| Broad sense heritability ($h^2_b$ %) | 92.09 | 94.26 | 36.01 | 0.00 | 74.13 | 75.59 | 9.41 |
| Narrow sense heritability ($h^2_n$ %) | 57.96 | 64.23 | 27.35 | 0.00 | 44.48 | 75.59 | 0.00 |

**Table 2 : Mean performance of all genotypes for vegetative traits, yield, yield component traits and oil percent at the combined data over the two locations.**

| Genotypes | Days to 50% flowering | Plant height in centimeters | Number of primary branches per plant | Number of silique per plant | Weight of 1000 seeds in grams | Seed yield per plant in grams | Oil percent |
|---|---|---|---|---|---|---|---|
| | Comb. | Comb. | Comb. | Comb. | Comb. | Comb. | Comb. |
| **Lines:** | | | | | | | |
| DH1 | 104.7 | 201.7 | 6.4 | 1000 | 3.45 | 45.9 | 45.4 |
| DH3 | 68.5 | 179.6 | 5.3 | 655.7 | 3.60 | 33.3 | 45.9 |
| DH4 | 81.5 | 174.4 | 5.5 | 919.4 | 3.88 | 64.2 | 45.3 |
| DH5 | 71.5 | 170.9 | 5.4 | 641.8 | 4.12 | 55.5 | 47.3 |
| DH6 | 97.5 | 198.6 | 5.7 | 957.2 | 3.88 | 51.9 | 45.2 |
| DH7 | 94.6 | 202.8 | 5.3 | 616.3 | 4.36 | 36.1 | 48.2 |
| DH8 | 97.5 | 197.7 | 6.5 | 950.6 | 3.79 | 55.0 | 45.8 |
| DH9 | 89.5 | 202.3 | 6.6 | 928.3 | 3.56 | 56.7 | 51.1 |
| **Testers:** | | | | | | | |
| Serw6 | 83.8 | 179.3 | 5.8 | 758.7 | 3.73 | 51.7 | 45.7 |
| Serw8 | 72 | 161.4 | 6.6 | 893.6 | 3.60 | 65.4 | 46.9 |
| **Hybrids:** | | | | | | | |
| DH1xSerw6 | 96.3 | 209.7 | 7.3 | 1211.3 | 3.59 | 81.0 | 42.2 |
| DH1xSerw8 | 100.1 | 225.8 | 7.8 | 1025 | 3.76 | 82.3 | 46.6 |
| DH3xSerw6 | 83.1 | 190.6 | 7.8 | 979.6 | 3.76 | 74.6 | 50.0 |
| DH3xSerw8 | 90.7 | 193.5 | 6.8 | 1118.4 | 3.56 | 79.9 | 48.8 |
| DH4xSerw6 | 83 | 185.9 | 6.0 | 827.7 | 4.16 | 59.8 | 48.3 |
| DH4xSerw8 | 81.8 | 186.2 | 7.1 | 991.9 | 3.51 | 75.8 | 46.2 |
| DH5xSerw6 | 81.5 | 187.7 | 7.7 | 1073.5 | 3.76 | 60.6 | 43.5 |
| DH5xSerw8 | 68.1 | 159.6 | 6.3 | 865.4 | 3.55 | 69.6 | 46.1 |
| DH6xSerw6 | 89.1 | 208.5 | 7.2 | 1136.8 | 4.00 | 63.0 | 50.3 |
| DH6xSerw8 | 93.3 | 209.6 | 7.0 | 926.6 | 4.02 | 57.8 | 41.1 |
| DH7xSerw6 | 88.6 | 200.1 | 6.4 | 847 | 4.17 | 59.5 | 46.7 |
| DH7xSerw8 | 91.8 | 197.7 | 6.6 | 1202.1 | 4.14 | 74.7 | 44.5 |
| DH8xSerw6 | 89.1 | 197.7 | 8.0 | 1083.7 | 4.01 | 59.3 | 42.6 |
| DH8xSerw8 | 98 | 215.5 | 8.0 | 1155.5 | 3.97 | 57.5 | 46.7 |
| DH9xSerw6 | 87.3 | 185.7 | 7.8 | 1151.7 | 3.93 | 71.7 | 44.4 |
| DH9xSerw8 | 91.5 | 185.8 | 7.7 | 1338.8 | 3.68 | 89.4 | 45.7 |
| LSD 5% | 2.955 | 5.519 | 1.049 | 119.1 | 0.085 | 7.679 | 2.55 |
| 1% | 3.919 | 7.320 | 1.391 | 157.9 | 0.113 | 10.18 | 3.38 |