LINE X TESTER ANALYSIS FOR YIELD AND FIBER QUALITY IN COTTON (Gossypium hirsutum L.)

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ABSTRACT

This experiment was conducted in order to estimate gene action, combining ability and heterotic effects for yield and quality characters by the line x tester analysis, involving 5 lines and 4 testers with 20 crosses in cotton (Gossypium hirsutum L.). The ratio of general and specific ability variance revealed non-additive gene action effects for seed cotton yield, fiber length, fiber strength and ginning percentage and additive gene action for fiber fineness and reflectance degree. Claudia, Gloria and Bali 308 with high general combining ability were the best combiner parents and could be used for breeding multi-parent combinations. ST-468 x Claudia, Carisma x Carmen, Bali 308 x Gloria and Bali 308 x Claudia were promising combinations for further selection. Heterosis and heterobeltiosis values of most cross combinations for seed cotton yield, fiber strength and ginning percentage were negative direct. It was concluded that due to non-additive gene actions, it is advisable to select individual plants for seed cotton yield, ginning percentage and fiber traits in later generations (F4-F6).

Key words: Combining ability, cotton, fiber quality, gene action, heterosis, yield

INTRODUCTION

The primary objectives of a cotton breeding are high yield and suitable fiber quality parameters. The information on heritability, combining ability and heterotic effects for yield and quality characters in cotton can be estimated from the analysis of data on a diallel mating scheme, the so-called diallel analysis, which was introduced by Griffing (1956). It is known that the technique of diallel analysis, which is simple and easy to use, can be widely applied in studies of cotton breeding programmes, with the exception of the race between different lines of cotton (Greveniotis et al., 2018). Reflectance degree of cotton fiber is a measure of the intensity of light reflected by the fiber. The reflectance degree of cotton fiber is determined by reflectance degree of cotton fiber. The color grade of cotton is determined by reflectance degree (Rd) and yellowness (+b), and reflectance degree indicates the more stable quantitative behavior than yellowness (Greveniotis et al., 2018). The ratio of $\sigma^2$GCA / $\sigma^2$SCA could be useful in order to estimate the behavior of a segregating generation. Many researchers reported that seed cotton yield, fiber length, fiber strength and ginning percentage controlled by non-additive gene effect (Khokhar et al., 2018; Munir et al., 2018; Patil et al., 2018). Therefore, selection for improvement should be delayed to late generations (F4-F6). Reflectance degree exhibited moderate heritability estimates (Amanu, 2018).

Heterosis is to estimate the performance of an F1, produced by the crossing of two varieties or pure lines but the use of heterosis in cotton has not yet reached the successive level. In conventional breeding programmes, heterotic effects are used to determine the dominance or epistatic variance and the promising cross combinations. Zerihun et al. (2004), Lingaraja et al. (2017), Coban and Unay (2017) and Adsare et al. (2017) reported the moderately high and positive heterosis values for seed cotton yield whereas mostly low and negative values for ginning percentage and fiber quality parameters were determined by Dhamayanthi (2011).

The present study was aimed to evaluate gene action, combining ability and heterotic effects of yield and fiber quality characters in cotton consisting of five lines and four testers. Especially, there is little information on genetic-statistics parameters of reflectance degree of fiber. The parents use as the tester in our study, Claudia, Gloria, Julia and Carmen, are prominent cotton varieties in terms of reflectance degree of cotton fiber.
MATERIALS AND METHODS

This research was conducted at the experimental area of Soke Oil Company, Aydınlıkuş, Turkey during 2013 and 2014 growing years. The experimental material consists of five lines viz., Lider, ST-468, Carisma, Flash, and Bali 308, and four testers; Gloria, Claudia, Julia, and Carmen were crossed in line x tester mating design to produce twenty F₁ crosses. Parents and their crosses were grown in randomized complete block design with three replications. All the cultural managements such as plant density, sowing date, fertilization and irrigation were applied as recommended for the cotton growing of Aegean Region. Seed cotton yield (SCY; kg ha⁻¹), fiber fineness (FF; mi.), fiber length (FL; mm), and fiber strength (FS; g tex⁻¹) and ginning percentage (GP; %) and reflectance degree of fiber (Rd) were recorded.

The variance analysis of line x tester suggested by Singh and Chaudhary (1979) was estimated using Microsoft Excel. Combining ability effects, heterosis and heterobeltiosis were computed for each characteristic. The critical values (CD) for the significance of the heterosis (Ht) and heterobeltiosis (Hb) was tested by following standard errors.

\[ CD \text{ for Ht at } 5\% = (3\text{Mean square of error}/2r)\text{1/2} \times t_{(0.05)} \text{ and } t_{(0.01)} \]

\[ CD \text{ for Hb at } 5\% = (2\text{Mean square of error}/r)\text{1/2} \times t_{(0.05)} \text{ and } t_{(0.01)} \]

RESULTS AND DISCUSSION

Line x Tester Analysis and ratios of \( \sigma^2 \text{GCA} / \sigma^2 \text{SCA} \)

Analysis of variance showed that genotypic differences were significant for the characters (Table 1). Also, significant differences among parents and crosses indicated the presence of genetic diversity for all characters. The mean squares of parent versus crosses were significant for SCY, FF, FL, and Rd. The differences between the overall mean of parents and their crosses indicate that crosses have advantages for FF, FL and Rd whereas parents have higher values for SCY. The interaction of line x tester was significant for all characteristics except FF.

| Source       | df | SCY  | FF    | FL    | FS    | Rd    | GP    |
|--------------|----|------|-------|-------|-------|-------|-------|
| Replications | 2  | 2741.18 | 0.03 | 0.25 | 0.90 | 1.49 | 0.07  |
| Genotypes    | 29 | 31963.96 | ** 4.18 | ** 2.49 | ** 7.11 | ** 12.17 | ** 6.56 |
| Parents      | 8  | 34170.25 | ** 5.81 | ** 2.91 | ** 19.20 | ** 5.32 | ** 3.65 |
| Crosses      | 19 | 33352.03 | ** 2.76 | ** 2.15 | ** 2.63 | ** 12.65 | ** 8.48 |
| P versus C   | 1  | 19904.15 | ** 22.22 | ** 8.14 | ** 2.62 | 70.09 | ** 0.05 |
| Lines        | 4  | 61877.42 | ** 7.10 | ** 4.32 | 1.64 | 43.11 | ** 4.92 |
| Testers      | 3  | 54905.75 | ** 3.04 | ** 2.85 | 3.46 | ** 4.19 | ** 17.00 |
| Line x Tester| 12 | 18455.14 | ** 1.25 | ** 1.25 | 2.76 | ** 4.61 | ** 7.64 |
| Error        | 58 | 3439.70 | 0.43 | 0.26 | 1.19 | 1.32 | 0.28  |

GCA/SCA 0.72 1.79 0.78 -0.18 2.93 -0.09

\(a, **; \text{significant at } 1\% \text{ and } 5\% \text{ probability level, respectively.}\)

High GCA to SCA variance ratio indicated preponderance of additive gene action. The additive gene actions for FF and Rd; non-additive gene actions (dominant or epistasis) for SCY, FL, FS and GP were estimated. The variance ratio of GCA to SCA below 1 (0.72) indicates the role of non-additive gene action for the inheritance of SCY. Similar results were reported by Kaleem et al. (2016), Shafeek et al. (2016), Khokhar et al. (2018), Komala et al. (2018), Patil et al. (2018), Prakash et al. (2018) and Roy et al. (2018).

Also, non-additive gene effects for FL, FS and GP were predominant according to variance ratio of GCA to SCA with below 1. Our findings were in accordance with Khokhar et al. (2018); Munir et al. (2018); Patil et al. (2018). But Prakash et al. (2018) revealed that these characteristics were controlled by additive gene effects.

In our study, variance ratio values of GCA to SCA for FF and Rd were determined as 1.79 and 2.93, respectively. It was shown that FF and Rd were managed largely by additive gene effects. Our results were similar to Prakash et al. (2018) but Munir et al. (2018) and Patil et al. (2018) were found non-additive gene effects for FF. This contradiction may be due to genotypic material and different mating design.

GCA and SCA effects

Significant GCA effects were detected for yield components, SCY and all fiber quality characteristics (Table 2). Among the parents Bali 308, Claudia and Carmen exhibited significant positive GCA effects for SCY. However, Lider, ST-468 and Julia were significant negative GCA effects for SCY. For FF, Lider would be promising to develop thinner fiber progenies. GCA effects of other parents and SCA effects of all crosses were non-significant in terms of FF. Bali 308, Flash and Carmen with positive and significant GCA effects contributed to the increase in FL in their combinations which crossed with. Carmen was the best combiner for FS because of its significant and positive GCA effects. Bali 308, Flash and Gloria for Rd; Claudia and ST-468 for GP had significant and positive GCA effects.
The SCA effects revealed that the best specific combinations were Lider x Gloria, Flash x Julia, Carisma x Carmen and ST-468 x Carmen for SCY; Carisma x Carmen for FL; Lider x Carmen and Bali 308 x Gloria for FS; Lider x Gloria for Rd; Carisma x Carmen, Bali 308 x Carmen and Carisma x Gloria, Flash x Claudia and Lider x Julia for GP (Table 2).

**Table 2. GCA and SCA effects of observed characters.**

| Lines      | SCY    | FF     | FL     | FS     | Rd     | GP     |
|------------|--------|--------|--------|--------|--------|--------|
| Lider      | -53.75** | -0.35* | -0.40** | -0.16 | -0.60* | -0.78**|
| ST-468     | -54.75** | 0.08   | -0.31** | 0.25  | -2.13** | 0.26*  |
| Carisma    | -9.42   | 0.24   | -0.56** | 0.50  | -1.12** | 0.83** |
| Flash      | -3.08   | 0.18   | 0.42**  | -0.15 | 1.29**  | 0.17   |
| Bali 308   | 121.00**| -0.15  | 0.84**  | -0.16 | 2.56**  | -0.50**|

**Crosses**

| Tester     | SCY    | FF     | FL     | FS     | Rd     | GP     |
|------------|--------|--------|--------|--------|--------|--------|
| Gloria     | 24.72  | -0.11  | 0.02   | -0.43  | 0.50*  | -0.31**|
| Claudia    | 34.32* | 0.19   | 0.17   | 0.05   | 0.05   | 1.55** |
| Julia      | -90.55**| -0.11  | -0.61**| -0.27  | -0.74**| -0.76**|
| Carmen     | 31.52* | 0.03   | 0.42**  | 0.65*  | 0.19   | -0.48**|

**Crosses**

| Lines      | SCY    | FF     | FL     | FS     | Rd     | GP     |
|------------|--------|--------|--------|--------|--------|--------|
| Lider x Carmen | 129.28** | 0.22   | 0.01   | -0.52  | 2.84** | -0.31  |
| Lider x Claudia | -82.32** | 0.16   | 0.25   | -0.27  | -1.24* | 0.46   |
| Lider x Julia  | -65.78* | -0.41  | -0.38  | -0.78  | -0.38  | 0.57*  |
| Lider x Carmen | 18.82   | 0.03   | 0.12   | 1.56** | -1.12* | -0.71**|
| ST-468 x Carmen | -55.05  | -0.14  | -0.57* | -0.86  | -0.86  | -0.30  |
| ST-468 x Claudia | 71.02*  | 0.19   | 0.38   | 0.66   | 0.99   | 0.74** |
| ST-468 x Julia  | -1.78   | 0.09   | 0.16   | 0.55   | -1.05  | 0.09   |
| ST-468 x Carmen | -14.18  | -0.14  | 0.03   | -0.35  | 0.92   | -0.53* |
| Carisma x Gloria | -42.38  | -0.07  | -0.39  | -0.47  | -0.60  | 1.29** |
| Carisma x Carmen | 86.35** | -0.28  | -0.65* | -0.52  | -0.35  | -3.61**|
| Carisma x Julia  | -70.78* | 0.26   | -0.15  | 0.47   | 0.38   | -0.53* |
| Carisma x Carmen | 26.82   | 0.08   | 1.19** | 0.51   | 0.58   | 2.86** |
| Flash x Gloria  | -60.72* | 0.05   | 0.62*  | 0.35   | -1.21* | 0.14   |
| Flash x Claudia  | -29.65  | -0.07  | 0.42   | 0.83   | 0.37   | 0.81** |
| Flash x Julia   | 117.22**| 0.03   | 0.10   | -0.24  | 0.90   | 0.05   |
| Flash x Carmen  | -26.85  | -0.02  | -1.15**| -0.94  | -0.07  | -1.00**|
| Bali 308 x Gloria | 28.87   | -0.06  | 0.32   | 1.49** | -0.18  | -0.82**|
| Bali 308 x Carmen | -45.40  | -0.01  | -0.40  | -0.70  | 0.23   | 1.61** |
| Bali 308 x Julia  | 21.13   | 0.02   | 0.27   | -0.01  | 0.16   | -0.17  |
| Bali 308 x Carmen | -4.60   | 0.05   | -0.19  | -0.80  | -0.21  | -0.62* |

*, **: significant at 1% and 5% probability level, respectively.

The mean performance of F₁ crosses and parental cultivars

There was a significant change in the performance of the parents for each character (Table 3). The range of SCY was between 302.67 kg da⁻¹ (Flash) and 649.67 kg da⁻¹ (Claudia). Lider was the highest FF value (5.43) whereas Gloria gave the lowest FF value (4.18). The longest fiber (31.13 mm) was calculated for Claudia, while Bali 308 was the shortest FL of 27.74 mm. Among parents, FS varied from 34.7 g tex⁻¹ (Gloria) to 28.3 g tex⁻¹ (Carisma). Also, among the lines and testers, the highest and lowest GP were obtained for Claudia (45.37 %) and Bali 308 (41.90 %). In the case of Rd, the lowest (73.70) and the highest (78.37) values were produced by ST-468 and Gloria, respectively. The mean of lines and tester were 75.1 and 76.8 for Rd, respectively.

The crosses differentiated dramatically for each trait (Table 3). The mean SCY ranged between 241.00 kg da⁻¹ (Lider x Julia) and 625.67 kg da⁻¹ (Bali 308 x Gloria). ST-468 x Carmen revealed the highest FF value (5.00 mic.) whereas revealed the lowest FF value (3.68 mic.) was obtained for Lider x Julia. Bali 308 x Gloria was the longest fibers (30.50 mm) while Lider x Julia gave the shortest FL of 28.06 mm. Among combinations, Lider x Carmen had the strongest fibers (34.50 g tex⁻¹) and Lider x Julia had the weakest fibers (30.70 g tex⁻¹). Also, among the hybrids Carisma x Carmen had the highest GP (46.50 %) and Lider x Carmen had the lowest GP (41.33 %). In case of Rd, the highest (77.25) and the lowest (74.75) values were produced by Carisma x Gloria and ST-468 x Carmen, respectively. The mean of crosses (76.05) shown that F₁ population had higher values in a positive direction.
Table 3. Mean values of observed characters.

| Lines            | SCY  | FF   | FL   | FS   | Rd   | GP   |
|------------------|------|------|------|------|------|------|
| Lider            | 452.00 | 5.43 | 28.73 | 31.23 | 75.27 | 44.23 |
| ST-468           | 519.67 | 4.83 | 28.67 | 34.07 | 73.70 | 43.20 |
| Carisma          | 522.00 | 5.40 | 27.93 | 28.37 | 76.13 | 44.43 |
| Flash            | 302.67 | 5.34 | 28.90 | 31.80 | 75.03 | 42.93 |
| Bali 308         | 408.33 | 4.75 | 27.74 | 28.73 | 75.53 | 41.90 |
| **Tester**       |      |      |      |      |      |      |
| Gloria           | 607.67 | 4.18 | 29.11 | 34.70 | 78.37 | 42.87 |
| Claudia          | 649.67 | 4.95 | 31.13 | 34.47 | 77.10 | 45.37 |
| Julia            | 406.33 | 4.44 | 28.39 | 34.53 | 76.60 | 42.83 |
| Carmen           | 485.67 | 4.65 | 28.42 | 34.10 | 75.80 | 42.40 |
| **Mean (Parents)** | 483.77 | 4.89 | 28.78 | 32.44 | 75.94 | 43.35 |
| **Crosses**      |      |      |      |      |      |      |
| Lider x Carmen   | 551.33 | 4.30 | 29.08 | 32.30 | 76.82 | 41.90 |
| Lider x Claudia  | 349.33 | 4.55 | 29.47 | 32.50 | 76.18 | 44.53 |
| Lider x Julia    | 241.00 | 3.68 | 28.06 | 30.70 | 75.93 | 42.33 |
| Lider x Carmen   | 447.67 | 4.25 | 29.58 | 34.50 | 75.53 | 41.33 |
| ST-468 x Carmen  | 366.00 | 4.36 | 28.59 | 31.37 | 76.03 | 42.97 |
| ST-468 x Claudia | 501.67 | 5.00 | 29.65 | 33.37 | 75.40 | 45.87 |
| ST-468 x Julia   | 304.00 | 4.60 | 28.69 | 32.93 | 75.15 | 42.90 |
| ST-468 x Carmen  | 413.67 | 4.50 | 29.57 | 32.97 | 74.75 | 42.57 |
| Carisma x Gloria | 424.00 | 4.60 | 28.52 | 32.17 | 77.25 | 45.10 |
| Carisma x Claudia| 562.33 | 4.70 | 28.40 | 32.60 | 76.62 | 42.07 |
| Carisma x Julia  | 280.33 | 4.94 | 28.13 | 33.27 | 76.37 | 42.83 |
| Carisma x Carmen | 500.00 | 4.89 | 30.49 | 34.23 | 75.97 | 46.50 |
| Flash x Gloria   | 412.00 | 4.66 | 30.50 | 33.23 | 76.70 | 43.30 |
| Flash x Claudia  | 452.67 | 4.84 | 30.46 | 34.20 | 76.07 | 45.83 |
| Flash x Julia    | 474.67 | 4.65 | 29.35 | 32.80 | 75.82 | 42.77 |
| Flash x Carmen   | 452.67 | 4.72 | 29.13 | 33.03 | 75.42 | 42.00 |
| Bali 308 x Gloria| 625.67 | 4.22 | 30.62 | 33.73 | 76.95 | 41.67 |
| Bali 308 x Claudia| 561.00 | 4.58 | 30.05 | 32.03 | 76.32 | 45.97 |
| Bali 308 x Julia | 502.67 | 4.31 | 29.94 | 32.40 | 76.07 | 41.87 |
| Bali 308 x Carmen | 599.00 | 4.47 | 30.50 | 32.53 | 75.67 | 41.70 |
| **Mean (crosses)** | 451.08 | 4.54 | 29.51 | 32.84 | 76.05 | 43.30 |
| **LSD (0.05)**   | 79.40 | 0.88 | 0.69  | 0.49  | 1.56  | 0.72  |

**Heterotic Effects**

Heterosis estimates of crosses combinations are presented in Table 4. Heterosis values for SCY ranged from 34% (Bali 308 x Carmen) to -43.84% (Lider x Julia). Bali 308 x Carmen, Flash x Julia, Bali 308 x Julia and Bali 308 x Gloria were significant and positive heterosis. Among the F1 crosses, the significantly but negative heterosis was estimated -25.50% (Lider x Julia) and -15.58% (Lider x Carmen) for FF. For FL, heterosis values were between -3.83 to 8.63% for the crosses. Bali 308 x Carmen, Carisma x Carmen, Bali 308 x Gloria, Bali 308 x Julia, Flash x Gloria, ST-468 x Carmen and Lider x Carmen combinations showed significant and positive heterosis. Regarding FS, the significant and positive heterosis values were estimated for Carisma x Carmen (9.61%), Bali 308 x Gloria and Lider x Carmen combinations. Although, Bali 308 x Carmen (6.30) were the highest significant positive heterosis Lider x Julia (-59.57) exhibited the lowest significant negative heterosis for Rd. The most significant positive and negative heterosis values for GP were found for Carisma x Carmen (7.10%) and Carisma x Claudia (-6.31%) combinations.

Heterobeltiosis estimates of hybrids were varied significantly for each character (Table 5). The values of heterobeltiosis ranged between -46.68% (Lider x Julia) and 23.33% (Bali 308 x Carmen) for SCY; -17.19% (Lider x Carmen) and 11.40% (Flash x Gloria) for FF; -8.76% (Carisma x Claudia) to 7.32% (Bali 308 x Carmen) for FL; -7.28% (Carisma x Claudia) and 4.66% (Carisma x Carmen) for GP; -11.09% (Lider x Julia) and 1.17% (Lider x Carmen) for FS; -59.92 (Lider x Julia) and 6.11% (Bali 308 x Carmen) for Rd. Unlike, no significant the value of heterobeltiosis for the crosses was estimated for FF.
It was determined that heterotic effects for SCY, FS and GP were mostly negative direction whereas numerous cross combinations showed positive heterosis and heterobeltiosis for FF, FL and Rd. Our results are similar to the findings of Solanki et al. (2014) and Khokhar et al. (2018).

**CONCLUSION**

The non-additive gene effects were predominant for seed cotton yield, fiber length, fiber strength and ginning percentage. Cultivar Claudia was the most suitable parent to combine crossing blocks for all traits. Also, Gloria and Bali 308 were good combiners for seed cotton yield but the cross combinations of these parents should be crossed with a combined with high GCA effects in terms of ginning percentage and fiber traits. The hybrids ST-468 x Claudia, Carisma x Carmen, Bali 308 x Gloria and Bali 308 x Claudia were the most promising for improving the yield and fiber traits. Moreover, out of four, two crosses viz., Bali 308 x Gloria and Bali 308 x Claudia involved both the parents have GCA effect for seed cotton yield. Higher heterosis and heterobeltiosis for SCY were

**Table 4. Heterosis values of observed characters**

|            | SCY  | FF   | FL   | FS   | Rd   | GP   |
|------------|------|------|------|------|------|------|
| Lider x Gloria | -9.27 | 2.79 | -0.11 | -6.92** | -58.79** | -5.27** |
| Lider x Claudia | -46.23** | -8.15 | -5.33** | -5.72* | -57.85** | -1.84** |
| Lider x Julia | -46.68** | -17.19 | -1.17 | -11.09** | -59.92** | -4.29** |
| Lider x Carmen | -7.82 | -8.53 | 4.08** | 1.17 | -54.49** | -6.55** |
| ST-468 x Gloria | -39.77** | 4.39 | -1.79 | -9.61** | -3.79** | -0.54 |
| ST-468 x Claudia | -22.78** | 3.45 | -4.78** | -3.20 | -0.39 | 1.09** |
| ST-468 x Julia | -41.50** | 3.60 | 0.17 | -6.42* | -3.44** | -0.69* |
| ST-468 x Carmen | -20.40* | -3.15 | 3.15** | -3.32 | 1.41 | -1.47** |
| Carisma x Gloria | -30.23** | 10.13 | -2.04 | -7.30** | -2.17* | 1.51** |
| Carisma x Claudia | -13.44* | -5.12 | -8.76** | -5.43* | -0.82 | 1.72** |
| Carisma x Julia | -46.30** | 11.26 | -0.93 | -3.66 | -0.26 | 3.59** |
| Carisma x Carmen | -4.21 | 5.16 | 7.30** | 0.39 | 1.84 | 4.66** |
| Flash x Gloria | -32.30** | 11.40 | 4.79** | -4.23* | 0.12 | 0.86* |
| Flash x Claudia | -30.32** | -2.29 | -2.16* | -0.78 | 3.24** | 1.02** |
| Flash x Julia | 16.80 | -12.98 | 1.57 | -5.01* | 3.57** | -0.38 |
| Flash x Carmen | -6.80 | 1.58 | 0.80 | -3.13 | 4.62** | -2.17** |
| Bali 308 x Gloria | 2.96 | 1.04 | 5.20** | -2.79 | 3.06** | -2.81** |
| Bali 308 x Claudia | -13.65* | -7.54 | -3.46** | -7.07** | 4.71** | 1.32** |
| Bali 308 x Julia | 23.10* | -2.93 | 5.46** | -6.17** | 4.26** | -2.25** |
| Bali 308 x Carmen | 23.33* | -3.94 | 7.32** | -4.59* | 6.11** | -1.65** |

*, **: significant at 1% and 5% probability level, respectively.

**Table 5. Heterobeltiosis values of observed characters**

|            | SCY  | FF   | FL   | FS   | Rd   | GP   |
|------------|------|------|------|------|------|------|
| Lider x Gloria | -9.27 | 2.79 | -0.11 | -6.92** | -58.79** | -5.27** |
| Lider x Claudia | -46.23** | -8.15 | -5.33** | -5.72* | -57.85** | -1.84** |
| Lider x Julia | -46.68** | -17.19 | -1.17 | -11.09** | -59.92** | -4.29** |
| Lider x Carmen | -7.82 | -8.53 | 4.08** | 1.17 | -54.49** | -6.55** |
| ST-468 x Gloria | -39.77** | 4.39 | -1.79 | -9.61** | -3.79** | -0.54 |
| ST-468 x Claudia | -22.78** | 3.45 | -4.78** | -3.20 | -0.39 | 1.09** |
| ST-468 x Julia | -41.50** | 3.60 | 0.17 | -6.42* | -3.44** | -0.69* |
| ST-468 x Carmen | -20.40* | -3.15 | 3.15** | -3.32 | 1.41 | -1.47** |
| Carisma x Gloria | -30.23** | 10.13 | -2.04 | -7.30** | -2.17* | 1.51** |
| Carisma x Claudia | -13.44* | -5.12 | -8.76** | -5.43* | -0.82 | 1.72** |
| Carisma x Julia | -46.30** | 11.26 | -0.93 | -3.66 | -0.26 | 3.59** |
| Carisma x Carmen | -4.21 | 5.16 | 7.30** | 0.39 | 1.84 | 4.66** |
| Flash x Gloria | -32.30** | 11.40 | 4.79** | -4.23* | 0.12 | 0.86* |
| Flash x Claudia | -30.32** | -2.29 | -2.16* | -0.78 | 3.24** | 1.02** |
| Flash x Julia | 16.80 | -12.98 | 1.57 | -5.01* | 3.57** | -0.38 |
| Flash x Carmen | -6.80 | 1.58 | 0.80 | -3.13 | 4.62** | -2.17** |
| Bali 308 x Gloria | 2.96 | 1.04 | 5.20** | -2.79 | 3.06** | -2.81** |
| Bali 308 x Claudia | -13.65* | -7.54 | -3.46** | -7.07** | 4.71** | 1.32** |
| Bali 308 x Julia | 23.10* | -2.93 | 5.46** | -6.17** | 4.26** | -2.25** |
| Bali 308 x Carmen | 23.33* | -3.94 | 7.32** | -4.59* | 6.11** | -1.65** |

*, **: significant at 1% and 5% probability level, respectively.
observed whereas mostly lower values for fiber traits and ginning percentage were estimated. It was concluded that due to non-additive gene actions, it is advisable to select individual plants for seed cotton yield, ginning percentage and fiber properties in later generations (F4-F8).

LITERATURE CITED

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