Heterosis Studies for Seed Cotton Yield and Fibre Quality Traits in Upland Cotton (Gossypium hirsutum L.)

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ABSTRACT

Background: Cotton hybrids has its own advantage than varieties in yield and fibre properties. Heterosis breeding helps in identifying F₁ hybrids and in creating variability. The chief intention of any hybridization programme is to combine all the desirable genes present in two or more parents into a single genetic background.

Methods: This investigation helped in identifying the extent of heterosis in crosses among eight elite selected lines and five testers in upland cotton (Gossypium hirsutum L.) which was conducted at ARS Dharwad Farm during kharif 2017-18. The all 40 hybrids were derived by line × tester crossing which were analysed for productivity traits along with fibre quality in a randomised block design.

Result: The hybrids, CPD-462 × SCS-1061, FLT-36 × SCS-1061 and CPD-462 × NNDC-30 were the most potential crosses. Crosses CPD-462 × IH-11 and FLT-44 × NNDC-24 also recorded desirable fibre quality parameters. These crosses can be exploited for crop improvement programme as they registered high per se performance combined with significant heterosis for most of the yield and fibre quality traits. This study reveals good scope for commercial exploitation of heterosis as well as isolation of potential progenies from the heterotic F₁ hybrids.

Key words: Cotton (Gossypium hirsutum L.), Heterosis, Line × Tester, per se performance.

INTRODUCTION

Cotton (Gossypium spp.) is a crop of prosperity having influence on man and matter and called as ‘King of fibre’. It is also rightly called as ‘White Gold’. Cotton is one of the most important commercial crops and forms the backbone of Indian textile industry. No other fibre comes close to duplicating all of the desirable characteristics combined in cotton.

India has the largest area under cotton (122.38 lakh ha) with productivity of 501 kg ha⁻¹ and is the largest producer (361 lakh bales) as well as exporter of cotton yarn. (Anonymous, 2019). India is the only country growing cottons of all staples right from 15 mm to 40 mm length. Indian textile industries are predominantly cotton based. In India, more than 85% of area is covered by hybrid cotton and the cultivation of hybrids in turn has helped in gaining self-sufficiency in cotton production.

Hybridization is the most potent technique for breaking yield barriers. The yield of cotton hybrids is about 50% higher than varieties. Cotton is one of the few crops which is accessible to the development of genotypes as varieties and at the same time amenable for commercial exploitation of heterosis. Heterosis is the increased vigour of the F₁ generation over the mean of the parents or over the better parent. Heterosis is a complex genetical phenomenon. The chief intention of any hybridization programme is to combine all the desirable genes present in two or more parents into a single genetic background resulting in novel variability. These hybrids are utilized either by directly exploiting the hybrid vigour or advancing to further filial generations and selecting the superior individuals after attaining homozygosity.

India is a pioneer in commercialization of heterosis in cotton and many researchers have reported heterosis or hybrid vigour in cotton. The magnitude of heterosis provides a basis for exploiting the genetic diversity and serves as a guide to the choice of desirable parents. In the present investigation, line × tester analysis has been used to study the quantitatively inherited characteristics of upland cotton, with a view to identify the best heterotic crosses for plant yield, its attributing traits and fibre quality parameters. The prime objective of the present study was to estimate the extent of heterosis for yield and fibre quality traits among 40 crosses obtained by crossing 8 elite lines with 5 testers in a line × tester fashion in Gossypium hirsutum L.

MATERIALS AND METHODS

The genetic material for present investigation consisted of 40 hybrids which were obtained by crossing the eight elite lines viz., FLT-36, FLT-44, FLT-31, FLT-28, SG-1, SG-2, EL-
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4. CPD-462 with the five testers viz., NNDC-30, NNDC-24, NNDC-59, IH-11 and SCS-1061 in a L × T fashion along with three standard checks viz., DHH-11, DHH-263 and Ajeet-199 Bt. All the above genotypes were never used in any hybridisation activity till now.

This investigation was carried out at the Agricultural Research Station, Dharwad Farm which is under University of Agricultural Sciences, Dharwad during kharif 2017-18. The genetic material was laid out in a randomized block design with three replications. A spacing of 90 cm between rows and 60 cm between plants within a row for hybrids and 90 cm between rows and 20 cm between plants for parents was followed. The hybrids and parents were randomised amongst themselves and were sown in separate adjacent plots. Each entry was sown in two rows of 4.80 meters length. Data were recorded on five randomly selected plants per replication for major traits like days to 50 per cent flowering, plant height (cm), number of monopodia and sympodia per plant, number of bolls per plant, boll weight (g), seed cotton yield (kg ha⁻¹), ginning outturn, seed index, lint index (g), UHML (mm), fibre strength (g tex⁻¹) and micronaire (µg/inch). The Line × Tester analysis of heterosis was performed according to Kempthorne (1957) using the WINDOWSTAT statistical package. The crop was raised under rainfed condition with the recommended agronomic package of practices. Suitable plant protection measures were carried out to control pests and diseases at appropriate time.

**RESULTS AND DISCUSSION**

**a) Analysis of Variance**

The analysis of variance (Table 1) revealed that there were significant differences among the genotypes for all ten characters investigated. The mean sum of squares for parents was significant for most of the characters except for ginning outturn and lint index. The lines showed significant differences for most traits except for ginning outturn and lint index. Among the testers, significant differences were observed for number of monopodia, seed cotton yield and ginning outturn. The interaction between lines and testers was significant for plant height, number of monopodia per plant, number of sympodia per plant and number of bolls per plant. The interaction between parents and hybrids was found to be significant for all traits. The mean sum of squares with respect to hybrids was found to be significant for all traits except for number of sympodia per plant and ginning outturn. This depicted the presence of considerable genetic difference among the hybrids thus pointing towards effective selection of parents.

**b) Mean Performance**

Mean performance acts as the main criterion in selecting better hybrids as it reveals their real value. Shimna and Ravikesavan (2008) suggested that the per se performance of hybrids appeared to be a useful index in judging them and Gilbert (1958) reported that parents with good per se performance would result in good hybrids.

The mean range of crosses have been given in Table 2. The variation among the hybrids for mean performance for days to 50 per cent flowering varied from 58.07 days (FLT-36 × NNDC-30) to 63.70 days (CPD-462 × IH-11) and for plant height, the magnitude of variation among the hybrids for mean performance of this character was from 101.33 cm (FLT-28 × NNDC-30) to 141.80 cm (CPD-462 × NNDC-59). For monopodia per plant, the variation among the hybrids for mean performance for this character was from 0.40 (SG-2 × NNDC-30) to 2.20 (FLT-28 × IH-11) and for number of sympodia per plant, for number of bolls per plant the crosses ranged from 12.07 (SG-1 × NNDC-59) to 21.96 (FLT-31 × NNDC-59).

The variation of crosses for boll weight ranged from 3.75 (SG-1 × NNDC-30) to 5.03 g (FLT-31 × NNDC-59) and in case of seed index, the range of crosses varied from 9.10 g (FLT-36 × NNDC-24) to 13.26 g (SG-2 × IH-11). For ginning outturn, the mean performance among crosses ranged from 35.00 (SG-1 × NNDC-59) to 41.01 per cent (FLT-36 × SCS-1061). For lint index, among the crosses values ranged from 5.54 (SG-1 × NNDC-59) to 8.35 g (SG-2 × IH-11). For seed cotton yield, the mean performance

| Source of variation | df | DFF | PH | NMP | NSP | NBP | BW | SI | GOT | LI | SCY |
|---------------------|----|-----|----|-----|-----|-----|-----|----|-----|----|-----|
| Replication         | 2  | 0.23| 12.61| 0.06| 0.86| 2.10| 0.36| 0.54| 2.39| 0.83| 20500.67 |
| Treatments          | 52 | 4.20**| 428.11**| 0.54**| 4.30**| 40.73**| 0.43**| 1.30**| 10.01**| 1.06**| 190320.30** |
| Parents             | 12 | 4.07 *| 474.18**| 0.43**| 8.31**| 6.35**| 0.31**| 0.97**| 8.74 | 0.46 | 61995.08** |
| Lines               | 7  | 5.22 **| 472.28**| 0.45**| 11.05**| 3.83**| 0.41**| 1.10**| 2.34 | 0.10 | 59678.24** |
| Testers             | 4  | 1.99 | 95.36 | 0.44**| 0.59 | 3.11 | 0.13 | 0.86 | 19.73**| 0.87 | 76341.59** |
| Lines vs. Testers   | 1  | 4.31 | 2002.82**| 0.31**| 19.94**| 36.92**| 0.29 | 0.46 | 9.62 | 1.28 | 20826.92 |
| Parents vs.Crosses  | 1  | 17.18**| 4151.20**| 7.34**| 60.64**| 1430.07**| 4.48**| 7.45**| 120.04**| 19.45**| 701120.00** |
| Crosses             | 39 | 3.91**| 318.47**| 0.40**| 1.62 | 15.69**| 0.36**| 1.25**| 7.57 | 0.78 | 165425.50** |
| Error               | 104| 1.75 | 78.25 | 0.03 | 1.68 | 1.62 | 0.13 | 0.40 | 5.26 | 0.48 | 23666.29 |

Where,

- * significant at 5 and 1 per cent respectively
- DFF-Days to 50 per cent flowering, PH-Plant height, NMP-Number of monopodia per plant, NSP-Number of sympodia per plant, NBP-Number of bolls per plant, BW- Boll weight, SI-Seed index, GOT-Ginning outturn, LI-Lint index, SCY-Seed cotton yield.
among the hybrids ranged from 656.67 (FLT-31 × SCS-1061) to 1890.00 kg/ha (CPD-462 × SCS-1061).

In case of UHML, among the crosses, mean values ranged from 24.40 (FLT-36 × NNDC-24) to 29.20 mm (CPD-462 × IH-11 and FLT-31 × NNDC-30) and for fibre strength, among the crosses, mean values ranged from 20.40 g/tex (EL-4 × NNDC-24) to 27.90 g/tex (EL-4 × NNDC-30). In case of micronaire value, among crosses, lowest and highest values were found to be 4.08 µg/inch (EL-4 × NNDC-30) and 5.00 µg/inch (FLT-44 × NNDC-30) respectively.

b) Heterosis

Range of heterosis over mid parent, better parent and standard checks for yield and yield components have been given in Table 2. For days to 50 per cent flowering, the midparent heterosis ranged from -6.18 per cent (FLT-36 × NNDC-30) to 3.96 per cent (CPD-462 × IH-11) and over better parent from -7.01 per cent (FLT-36 × NNDC-30) to 2.35 per cent (FLT-31 × NNDC-30). Four crosses showed significant negative heterosis over all three checks viz., DHH-11, DHH-263 and Ajeet-199 Bt. These results were in agreement with those of Solanki et al. (2015a) and Solanki et al. (2015b). In case of plant height, the magnitude of mid parent heterosis ranged from -8.65 per cent (FLT-44 × NNDC-24) to 45.19 per cent (CPD-462 × NNDC-59) and over better parent varied from -14.63 per cent (FLT-36 × NNDC-24) to 44.11 per cent (CPD-462 × NNDC-59). None of the crosses showed positive significant heterosis over all three checks for plant height. These findings are in agreement with Baloch et al. (2014), Kencharaddi et al. (2015) and Monicashree et al. (2017).

For number of monopodia per plant, the range of mid parent heterosis varied from -44.00 per cent (EL-4 × NNDC-24) to 560.00 per cent (FLT-28 × IH-11). Among 40 crosses only one cross showed significant negative heterosis over all checks viz., DHH-11, DHH-263 and Ajeet-199 Bt. These results are in conformity with earlier reports of Chhavikant et al. (2017) and Monicashree et al. (2017). In case of sympodia per plant, the magnitude of heterosis over mid parent varied from -5.69 (FLT-31 × NNDC-59) to 23.41 per cent (SG-1 × NNDC-30) and in case of heterosis over better parent heterosis varied from -14.33 (FLT-31 × NNDC-59) to 19.41 per cent (EL-4 × NNDC-24). The cross FLT-44 × SCS-1061 and SG-2 × NNDC-24 showed significant positive heterosis over all three checks viz., DHH-11, DHH-263 and Ajeet-199 Bt. This was in agreement with Kencharaddi et al. (2015), Chhavikant et al. (2017), Monicashree et al. (2017) and Bilwal et al. (2018).

In case of number of bolls per plant, the range of heterosis over mid parent was from 29.16 per cent (SG-1 × NNDC-30) to 134.65 per cent (FLT-36 × NNDC-24) and over better parent varied from 3.95 (SG-1 × NNDC-30) to 118.01 per cent (FLT-36 × NNDC-24). For standard heterosis, two crosses (FLT-36 × NNDC-59 and FLT-36 × NNDC-24) showed positive and significant values over all three checks. These results are in agreement with earlier reports of Baloch et al. (2014), Chhavikant et al. (2017), Monicashree et al.

Table 2: Range of mean performance of crosses and heterosis over mid parent, better parent and standard checks for yield and yield component characters in cotton (G. hirsutum L.)

| Characters                  | Days to 50% flowering | Plant height (cm) | Number of monopodia per plant | Number of sympodia per plant | Number of bolls per plant | Boll weight (g) | Seed cotton yield (kg/ha) | Ginning outturn | Seed index (g) | Lint index (g) | UHML (mm) | Fibre strength (g/tex) | Micronaire (µg/inch) |
|-----------------------------|------------------------|-------------------|------------------------------|-----------------------------|--------------------------|----------------|--------------------------|----------------|----------------|----------------|-----------|-------------------------|----------------------|
| Min                          | 56.07                  | 16.65             | 35.75                        | 1.04                        | 2.50                     | 0.35          | 6.90                     | 1.10           | 1.00           | 1.00           | 12.07     | 19.00                   | 4.00                  |
| Max                          | 63.70                  | 14.10             | 35.75                        | 1.04                        | 2.50                     | 0.35          | 6.90                     | 1.10           | 1.00           | 1.00           | 12.07     | 19.00                   | 4.00                  |
| Mean                         | 60.52                  | 16.10             | 35.75                        | 1.04                        | 2.50                     | 0.35          | 6.90                     | 1.10           | 1.00           | 1.00           | 12.07     | 19.00                   | 4.00                  |
| Range                        | 4.65                   | 2.10              | 1.25                         | 0.03                        | 0.50                     | 0.15          | 3.00                     | 0.00           | 0.00           | 0.00           | 0.00      | 0.00                   | 4.00                  |
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For boll weight, magnitude of mid parent heterosis ranged from -8.50 per cent (EL-4 × SCS-1061) to 52.55 per cent (SG-1 × SCS-1061). The range of heterosis over better parent varied from -10.36 (SG-1 × IH-11) to 30.22 per cent (FLT-31 × NNDC-59). None of the crosses showed significant standard heterosis over all three checks. Similar reports were also made by Baloch et al. (2014), Chhavikant et al. (2017), Monica shree et al. (2017) and Bilwal et al. (2018).

In case of seed index, the range of mid-parent heterosis was from -8.28 to 30.87 per cent. While in case of better parent heterosis the range of heterobeltiosis was between -13.55 (FLT-28 × NNDC-30) and 25.84 per cent (SG-2 × IH-11). Cross SG-2 × IH-11 was the only cross which showed significant heterosis over checks DHH-11 and DHH-263. These results are in accordance with Nidagundi et al. (2012), Kencharaddi et al. (2015), Chhavikant et al. (2017), Monica shree et al. (2017) and Bilwal et al. (2018). The magnitude of heterosis for ginning outturn over mid parent ranged from -5.6 (EL-4 × NNDC-30) to 16.08 per cent (FLT-36 × SCS-1061) and over better parent heterobeltiosis ranged from -9.96 (EL-4 × NNDC-30) to 11.70 per cent (EL-4 × SCS-1061). Seven crosses had significant positive heterosis over all the three standard checks. These results were in accordance with Chhavikant et al. (2017), Monica shree et al. (2017) and Bilwal et al. (2018).

In case of lint index, the range of mid-parent heterosis was from -8.70 (EL-4 × NNDC-30) to 48.75 per cent (SG-2 × IH-11) and in case of better parent heterosis ranged from -11.24 (EL-4 × NNDC-30) to 44.55 per cent (SG-2 × IH-11). The cross SG-2 × IH-11 showed positive significant heterosis over all the three standard checks. These results were in accordance with Monica shree et al. (2017), Monica shree et al. (2017) and Bilwal et al. (2018).

| Characters         | Desirable crosses | Mean performance | Heterosis in per cent over Mean performance | F<sub>1</sub> | MP | BP | MP | BP | MP | BP | MP | BP | MP | BP |
|--------------------|------------------|------------------|--------------------------------------------|-------------|----|----|----|----|----|----|----|----|----|----|----|----|
| Seed cotton yield  | CPD-462 × SCS-1061 | 1172.03 692.00 1399.00 150.66 ** 131.62 ** 149.23 ** 85.93 ** 83.94 ** | | | | | | | | | | | | |
|                    | FLT-36 × SCS-1061 | 1269.50 692.00 1353.83 96.30 ** 95.64 ** 78.53 ** 33.19 ** 31.76 * | | | | | | | | | | | | | |
|                    | CPD-462 × NNDC-30 | 1172.03 999.33 1311.00 44.44 ** 31.19 ** 72.88 ** 28.97 * 27.59 * | | | | | | | | | | | | | |
|                    | FLT-36 × NNDC-59 | 1269.50 597.67 1266.83 97.17 ** 84.31 ** 67.05 ** 24.63 23.29 | | | | | | | | | | | | | |
|                    | FLT-36 × NNDC-24 | 1269.50 799.83 1258.00 69.18 ** 57.28 ** 65.89 ** 23.76 22.43 | | | | | | | | | | | | | |
|                    | Ajeet-199 Bt. (Check) | 1027.50 | | | | | | | | | | | | | |
| UHML(mm)           | CPD-462 × IH-11 | 24.80 25.50 29.20 16.10 14.51 1.39 12.31 3.91 | | | | | | | | | | | | | |
|                    | FLT-31 × NNDC-30 | 27.30 26.40 29.20 8.75 6.96 1.39 12.31 3.91 | | | | | | | | | | | | | |
|                    | FLT-44 × NNDC-24 | 27.00 27.30 28.80 6.08 5.49 0.00 10.77 2.49 | | | | | | | | | | | | | |
|                    | EL-4 × NNDC-59 | 27.60 27.10 28.80 5.30 4.35 0.00 10.77 2.49 | | | | | | | | | | | | | |
|                    | FLT-31 × SCS-1061 | 27.30 27.60 28.70 4.55 3.99 -0.35 10.38 2.14 | | | | | | | | | | | | | |
|                    | DHH-11 (Check) | 28.80 | | | | | | | | | | | | | |
| Fibre strength (g/tex) | EL-4 × NNDC-30 | 26.30 25.30 27.90 8.14 6.08 2.95 15.29 6.08 | | | | | | | | | | | | | |
|                    | FLT-31 × SCS-1061 | 26.60 24.30 27.60 8.45 3.76 1.85 14.05 4.94 | | | | | | | | | | | | | |
|                    | FLT-44 × NNDC-24 | 25.30 26.10 27.40 6.61 4.98 1.11 13.22 4.18 | | | | | | | | | | | | | |
|                    | FLT-31 × NNDC-30 | 26.60 25.30 27.30 5.20 2.63 0.74 12.81 3.80 | | | | | | | | | | | | | |
|                    | CPD-462 × IH-11 | 19.60 23.20 27.30 27.57 17.67 0.74 12.81 3.80 | | | | | | | | | | | | | |
|                    | DHH-11 (Check) | 27.10 | | | | | | | | | | | | | |

MP = Mid parent, BP = Better parent
** *, ** significant at 5 and 1 per cent respectively
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13.44 (FLT-28 × NNDC-30) to 14.03 per cent (FLT-44 × NNDC-30) and -16.14 (CPD-462 × IH-11) to 12.22 per cent (SG-2 × NNDC-59), respectively. The cross FLT-44 × NNDC-30 was found to have the highest heterotic value over all three checks. Similar results were reported by Tuteja and Agarwal (2014) and Monicashree et al. (2017). The mean performance and heterosis of top hybrids for yield and fibre characters are given in Table 3. Both mean performance and heterosis can utilized for selection of promising hybrids.

CONCLUSION

Among the 40 new intra hirsutum cotton hybrids studied, three crosses viz., CPD-462 × SCS-1061, FLT-36 × SCS-1061 and CPD-462 × NNDC-30 were the best hybrids. These hybrids exhibited a greater number of bolls per plant, higher seed index, higher ginning outturn with moderate boll weight and number of sympodia. They also showed above average satisfactory fibre properties, including fibre strength, length and fineness. Whereas, the crosses FLT-31 × NNDC-30, FLT-44 × NNDC-24 and EL × NNDC-59 possessed superior fibre qualities without compromising on yield. These were cotton hybrids where both fibre quality and yield have been enhanced simultaneously.

It is notable that the three best crosses in the study were also significantly higher yielding than the Bt. check. Among all the 40 crosses, two crosses showed longer fibre length over the superior fibre check, DHH-11. Five crosses had superior fibre strength over the same superior check. The best crosses, CPD-462 × SCS-1061, FLT-36 × SCS-1061 and CPD-462 × NNDC-30 need to be tested extensively over locations for possible release as commercial hybrids. These crosses can also serve further cotton breeding programs.

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