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# Heterosis Studies of Newly developed *intra-hirsutum* Cotton Hybrids for Seed Cotton and Lint Yield and their Performance for Economic, Morphological and Fibre Quality Traits under Rainfed condition in Cotton (*Gossypium hirsutum* L.)

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**ABSTRACT: Stagnation in yield is observed in cotton since last one decade across all the zones of country mainly because of involvement of parental lines with narrow genetic base. The present study was aimed to develop $F_1$ cotton hybrids by involving parents with wide genetic base for commercial exploitation of useful and standard heterosis for seed cotton yield as estimation of heterosis over mid parent and better parent may not be given desirable cross combinations over commercially cultivated varieties or hybrids. Fifty *intra-hirsutum* cotton hybrids developed during *kharif* season of 2017-2018 from Line × Tester mating design (5 lines × 10 testers) were evaluated in randomised block design with two replications at Cotton Research Station, Nanded during *kharif* season of 2018-2019 along with one local varietal check, NH 615 for estimating useful heterosis and three standard hybrid checks *viz.*, NCS 145, NHH 250 and NHH 44 for estimating standard heterosis for seed cotton yield and lint yield. The analysis of variance showed significant differences among the crosses for all the traits. For earliness parameters, hybrids *viz.*, NHH 1245, NHH 1187, NHH 1109 and NHH 1189 were found promising., whereas two hybrids *viz.*, NHH 1200 (40.60 %) and NHH 1240 (39.85%) recorded highest ginning outturn, while hybrids viz., NHH 1166 (29.20 mm) and NHH 1204 (29.1 mm) recorded highest upper half mean length. The hybrids NHH 1166 and NHH 1139 (22.00 g/tex ) recorded highest fibre strength and NHH 1154 (2.35 ug/inch) and NHH 1198 (2.97 ug/inch) exhibited fine micronaire. Five hybrids *viz.*, NHH 1245 (2389 kg/ha), NHH 1235 (1910 kg/ha), NHH 1204 (1862 kg/ha), NHH 1165 (1832 kg/ha) and NHH 1075 (1817 kg/ha) were found most heterotic combinations for seed cotton yield and lint yield and may be utilized on large scale for commercial exploitation of heterosis and also for further transformation of BG II gene into parental lines of these hybrids to fulfil the demand of the cotton cultivators.**

**Keywords:** *Gossypium hirsutum, intra-hirsutum* hybrids, useful heterosis, standard heterosis seed cotton yield, mean performance.

## INTRODUCTION

Cotton, is the world's most popular natural fiber and always remains as the undisputed "king" of the global textiles industry almost pure and soft cellulose, (Monicashree *et al*., 2017). Cotton, continues to ascertain its importance as the most premiere crop of commerce in India besides providing job opportunities to millions of people. In India cotton is grown mostly in central zone (Gujarat, Maharashtra, Madhya Pradesh), south zone (Telangana, Andhra Pradesh, Karnataka, Tamilnadu), north zone (Punjab, Haryana, Rajasthan) and Odissa state. The average area, production and productivity of cotton in India is 129.57 Lakh hectares, 371 Lakh bales and 487 kg/ha, respectively (Anonymous, 2021). Average lint productivity of Maharashtra state is only 349 kg/ha which is nearly 30 per cent less than average National productivity. The main reason of low productivity of cotton in the country is mainly due to rainfed cultivation. Heterosis is the phenomenon in which the $F_1$ of two genetically dissimilar parents show increased vigour for various traits over the commercial variety (Useful heterosis) or Standard Hybrid check (Standard heterosis) . Heterosis is the phenomenon in which the F1 of two genetically dissimilar parents show increased vigor for various characters over the mid parent (relative heterosis) or better parent (heterobeltiosis) or the standard check (standard heterosis). With the introduction of BT cotton in the country during 2002-2003, gradual increase in seed cotton yield was observed for twelve years upto 2014-2015, thereafter yield stagnation is witnessed in all the cotton growing zones of the country. Presently, more than 700 cotton hybrids were released for commercial cultivation by public and private seed companies which are having very narrow genetic base due to limited variability in parental lines which is one of the main reason for cessation in yield plateau of cotton. Therefore, efforts have been made to develop high yielding *intra-hirsutum* hybrids of cotton coupled with superior fibre properties by involving parental lines with broad genetic base. Through heterosis, seed cotton yield and quality traits can be improved significantly (Naquibullah *et al.*, 2000).

## MATERIALS AND METHODS

Stagnation in Seed cotton yield (kg/ha) yield is observed in cotton since last one decade across all the zones of country mainly because of involvement of parental lines with narrow genetic base. The present study was aimed to develop $F_1$ cotton hybrids by involving parents with wide genetic base for commercial exploitation of useful and standard heterosis for seed cotton yield as estimation of heterosis over mid parent and better parent may not be given desirable cross combinations over commercially cultivated varieties or hybrids. Seed of $F_1$ cotton hybrids was developed during *kharif* season of 2017-2018 from Line × Tester mating design (5 lines × 10 testers) by conventional method of hybridization i.e hand emasculation and pollination method. The L × T analysis of heterosis was performed as suggested by Kempthrone (1957). Crossing program was initiated immediately after 50 per cent days to flowering. Fully developed flower buds, likely to open the next day were chosen for emasculation and anthers of selected buds were removed gently by skilled labours with the help of nail and further covered with red coloured straw tube to prevent natural out crossing. Emasculation was carried out between 3 and 6 P.M. The emasculated buds were pollinated on next day morning with pollen of male parent between 8.0 A.M. and 12 P.M. Four to five flower buds of female parent were pollinated by one flower of male parent to develop fifty cotton hybrids. These newly developed fifty cotton hybrids developed were further evaluated in randomised block design with two replications at Cotton Research Station, Nanded during *kharif* season of 2018-2019 along with one local varietal check, NH 615 for estimating useful heterosis and three standard hybrid checks *viz.,* NCS 145, NHH 250 and NHH 44 for estimating standard heterosis for seed cotton yield (kg/ha) and lint yield (kg/ha). Recommended spacing of 90 × 60 cm between row to row and plant to plant were followed with net plot size of 1.8 x 4.8 $m^2$ for each entry. Observations were recorded on randomly selected five plants for seed cotton yield (kg/ha), lint yield (kg/ha), ginning outturn (%), boll weight (g), seed index, lint index, number of bolls per plant, number of monopodia per plant, no of sympodia per plant, plant height (cm), days to fifty per cent flowering and days to first boll bursting. In addition, fibre quality parameters *viz.,* Upper Half Mean Length (mm), micronaire (µg/inch), bundle strength (g/tex), elongation (%), uniformity index (%), maturity ratio and per cent maturity (%) were estimated at HVI machine available at cotton research station, Nanded. Recommended agronomical practices and plant protection measures were followed as and when required to raise a good crop of cotton. Useful and standard heterosis was calculated as per standard method suggested by Phundan Singh (2006).

Useful and Standard heterosis refers to the superiority of $F_1$ over the commercial varietal check and commercial hybrid check, respectively. Useful and standard heterosis is calculated by using the following formula

$$\text{Useful Heterosis (UH\%)} = \frac{(\overline{F}_1 - \overline{VC})}{\overline{VC}} \times 100$$

Where, $F_1$ = Mean performance of $F_1$

VC= Mean performance of the varietal check

$$\text{Standard Heterosis (SH\%)} = \frac{(\overline{F}_1 - \overline{HC})}{\overline{HC}} \times 100$$

Where, $F_1$ = Mean performance of $F_1$

HC= Mean performance of the hybrid check

Heterosis leads to increase in yield, reproductive ability, adaptability, disease and insect resistance, general vigour, quality etc. For most of the characters, the desirable heterosis should be positive. But for some traits like days to first flower initiation, days to fifty per cent flowering and days to first boll bursting, negative heterosis is desirable.

## RESULTS AND DISCUSSION

### Analysis of Variance (ANOVA)

Analysis of variance was carried out to test the significant differences among the genotypes for seed cotton yield and related traits. Results were found significant for all the traits studied (Table 1).

**(a) Performance for seed cotton and lint yield (kg/ha).** Mean performance is an important selection criterion as it reveals their potential value of the parents or hybrids. In case of cotton, mean performance of parents or hybrids for seed cotton yield and lint yield is most important criteria for their selection as potential hybrids as compared to any check varieties before introducing them in the market on large scale. The demand of cotton farmers is always for high seed cotton yield varieties followed by other traits like big boll size, pest and disease tolerance and fibre quality traits. Shimna and Ravikesavan (2008) suggested that the per se performance of hybrids appeared to be an useful index in judging them and Gilbert (1958) reported that parents with good per se performance would result in good hybrids.

**Table 1: ANOVA table of newly developed *intra hirsutum* hybrids of cotton for seed cotton yield and other attributing traits under rainfed condition at Nanded.**

| Source of Variation | DF | Seed Cotton Yield (kg/ha) | Lint Yield (kg/ha) | Economic traits | | | | Morphological traits | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | GOT (%) | Boll wt. (g) | Seed Index | Lint index | number of bolls per plant | number of monopodia per plant | number of sympodia per plant | Plant height (cm) | days to 1st flower initiation | days to 50 % flowering | days to 1st boll bursting |
| Replications | 1 | 1,27,376.68** | 2670.083** | 33.275** | 0.389** | 5.094** | 0.004 | 304.691** | 2.196** | 12.002** | 114.717** | 9.481** | 3.343** | 7.259** |
| Treatment | 53 | 333975.561** | 49480.01** | 7.738** | 0.541** | 0.926** | 0.528** | 55.678** | 0.252** | 7.987** | 311.079** | 8.358** | 7.433** | 17.301** |
| Error | 53 | 36862.204 | 5415.951 | 2.581 | 0.19 | 0.611 | 0.333 | 15.849 | 0.145 | 2.83 | 99.29 | 1.161 | 0.909 | 1.184 |

* and ** indicates significance at 5 and 1 per cent level respectively.

**(i) Seed cotton yield (kg/ha):** Results were statistically significant for seed cotton yield (kg/ha) and it was ranged from 343 kg/ha (NHH 1104) to 2349 kg/ha (NHH 1245). As many as twelve hybrids depicted significant superiority over popular hybrid check, NCS 145 (1462 kg/ha) for seed cotton yield (kg/ha), whereas, five hybrids *viz.*, NHH 1245 (2349 kg/ha), NHH 1235 (1910 kg/ha), NHH 1204 (1862 kg/ha), NHH 1165 (1832 kg/ha) and NHH 1075 (1817 kg/ha) recorded significant superiority over varietal check, NH 615 (1331 kg/ha) and hybrid checks *viz.*, NHH 250 (1420 kg/ha) and NHH 44 (1338 kg/ha) for seed cotton yield.

**(ii) Lint yield (kg/ha) and ginning outturn (%) :** The *intra-hirsutum* hybrid NHH 1245 (892 kg/ha) recorded highest lint yield followed by NHH 1204 (715 kg/ha), NHH 1165 (681 kg/ha) and NHH 1235 (669 kg/ha). Six test hybrids *viz.*, NHH 1075 (642 kg/ha), NHH 1165 (681 kg/ha), NHH 1204 (715 kg/ha), NHH 1235 (669 kg/ha), NHH 1240 (641 kg/ha) and NHH 1245 (892 kg/ha) recorded significant superiority over varietal check., NH 615(638 kg/ha) whereas, four hybrids *viz.*, NHH 1245, NHH 1235, NHH 1204 and NHH 1165 depicted significant superiority over high yielding hybrid check., NHH 250 (667 kg/ha)

**(b) Morphological and yield contributing characters.** Performance of *intra-hirsutum* cotton hybrids with respect to morphological and other yield contributing characters are presented in Table 2.

**(i) Days to 50 percent flowering:** Days to 50 percent flowering was ranged from 75.50 days (NHH 1245) to 83.00 days (NHH 1104). Among the hybrids, NHH 1245 recorded lowest value for days to 50 percent flowering (75.50 days) followed by NHH 1189, NHH 1200, NHH 1238 and NHH 1240 (76.00 days each) indicating earliness. All these hybrids were recorded earliness as compared to varietal check, NH 615 (77.00 days) and hybrid check, NHH 44 (76.60 days), respectively.

**(ii) Days to first boll bursting:** Significant differences were observed for days to first boll bursting among all the hybrids studied. The hybrid NHH 1187 (99.50 days) recorded lowest value for days to first boll bursting indicating earliness. Hybrids NHH 1109, NHH 1154, NHH 1165 and NHH 1189 (100 days each) showed earliness over all the checks.

**(iii) Plant height (cm):** Wide range of variation was observed for plant height (66.80 to 124.50 cm). The highest plant height was recorded in hybrid NHH 1187 (124.50 cm) while lowest plant height was noted in hybrid NHH 1154 (66.80 cm). The hybrids NHH 1238 (115.10 cm) and NHH 1189 (113.90 cm) showed higher values for plant height over all the checks *viz.*, NH 615 (112.30 cm), NCS 145 (102.40 cm), NHH 250 (113.90 cm) and NHH 44 (114.00 cm).

**(iv) Number of sympodia per plant:** Number of sympodia per plant was ranged from 12.80 to 21.30. The highest number of sympodia was observed in NHH 1222 (21.30), while the lowest number of sympodia per plant was observed in hybrid NHH 1117 (12.80). The hybrids NHH 1115 (21.10), NHH 1215 (20.70), NHH 1211 (20.70), NHH 1212 (17.20) and NHH 1165 (20.20) recorded higher number of sympodia per plant over all the checks, *viz.*, NH 615 (17.10), NCS 145 (20.00), NHH 250 (18.90) and NHH 44 (19.60). Positive and significant heterosis in desirable direction were reported by Choudhary *et al.*, (2014); Solanki *et al.*, (2014); Kencharaddi *et al.*, (2015) for number of sympodial branches per plant.

**(v) Number of bolls per plant and boll weight (g):** Wide variation was observed for number of bolls per plant ranging from 16.60 to 42.10. Among the hybrids, the highest number of bolls per plant was noted in the hybrid NHH 1165 (42.10), while the lowest number of bolls per plant was observed in hybrid NHH 1166 (16.60). The hybrids NHH 1229 (40.60), NHH 1204 (36.80), NHH 1236 (32.60), NHH 1201 (32.00) and NHH 1215 (32.00) recorded higher number of bolls per plant over standard check NHH 44 (31.80).

Boll weight was ranged from 2.15 to 4.85 g. The hybrid NHH 1245 (4.85 g) recorded highest value followed by NHH 1165 (4.28 g), NHH 1240 (4.21 g), NHH 1187 (4.09 g) and NHH 1115 (3.99 g). Boll size has a strong negative correlation with earliness. Therefore, cotton breeders had always been made compromise to develop varieties with medium boll size to maximize cotton yield and an acceptable level of crop maturity. The results in the present investigation are in conformity with those reported by Aminul Islam *et al.*, (2021); Monicashree *et al.*, (2017).

**(vi) Seed index (g) and Lint index (g):** The character seed index ranged from 6.52 to 9.38 g. Among the hybrids, NHH 1226 and NHH 1139 (9.38 g each) exhibited highest value for seed index, while the hybrid NHH 1198 (6.52 g) expressed lowest value. The hybrids NHH 1109 (9.25 g), NHH 1125 (9.14 g) and NHH 1238 (9.11 g) showed high values of seed index over all the checks *viz.*, NH 615 (7.65 g), NCS 145 (8.93 g), NHH 250 (8.40 g) and NHH 44 (8.76 g).

## Table 2: Performance of newly developed *intra hirsutum* hybrids of cotton for seed cotton yield and other attributing traits under rainfed condition at Nanded.

| Sr. No. | Name of Hybrid | Seed Cotton Yield (kg/ha) | Lint Yield (kg/ha) | Economic traits | | | | Morphological traits | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | GOT (%) | Boll wt. (g) | Seed Index | Lint index | Number per plant | | | Plant height (cm) | Days to | | |
| | | | | | | | | Bolls | Mono podia | Sym podia | | 1st flower initiation | 50 % flowering | 1st boll bursting |
| 1. | NHH 1245 | **2349**$^*$ | 892$^*$ | 37.98 | 4.85 | 8.54 | 5.23 | 23.40 | 1.20 | 18.00 | 110.20 | 59.00 | 75.50 | 108.00 |
| 2. | NHH 1240 | 1605 | 641 | 39.85 | 4.21 | 7.37 | 4.89 | 24.30 | 1.50 | 16.20 | 96.20 | 58.00 | 76.00 | 106.00 |
| 3. | NHH 1239 | 919 | 316 | 34.43 | 3.12 | 8.53 | 4.48 | 19.90 | 1.80 | 17.60 | 96.60 | 59.50 | 78.50 | 101.00 |
| 4. | NHH 1238 | 1273 | 434 | 34.11 | 3.90 | 9.11 | 4.72 | 30.40 | 1.20 | 17.40 | 115.10 | 57.50 | 76.00 | 106.50 |
| 5. | NHH 1236 | 756 | 252 | 33.06 | 2.80 | 8.82 | 4.33 | 21.50 | 1.50 | 19.70 | 96.70 | 58.50 | 79.50 | 102.50 |
| 6. | NHH 1235 | **1910**$^*$ | 669$^*$ | 35.12 | 3.72 | 7.86 | 4.24 | 24.10 | 1.80 | 18.40 | 98.40 | 58.50 | 77.50 | 106.50 |
| 7. | NHH 1232 | 1279 | 457 | 35.78 | 3.54 | 7.69 | 4.27 | 25.40 | 2.00 | 16.50 | 89.90 | 56.00 | 79.50 | 108.50 |
| 8. | NHH 1231 | 1068 | 391 | 36.74 | 3.28 | 8.68 | 5.04 | 27.40 | 1.40 | 15.30 | 69.10 | 55.50 | 80.50 | 107.50 |
| 9. | NHH 1230 | 1625 | 555 | 34.26 | 3.68 | 8.75 | 4.52 | 27.20 | 1.00 | 16.90 | 110.70 | 53.00 | 77.00 | 105.50 |
| 10. | NHH 1229 | 1288 | 461 | 35.49 | 3.43 | 8.74 | 4.82 | 40.60 | 1.80 | 16.80 | 98.80 | 54.50 | 78.00 | 106.50 |
| 11. | NHH 1226 | 1157 | 366 | 31.75 | 3.35 | 9.38 | 4.39 | 26.20 | 1.50 | 17.20 | 100.20 | 56.50 | 78.00 | 108.00 |
| 12. | NHH 1225 | 1493 | 549 | 37.08 | 3.85 | 9.14 | 5.37 | 30.80 | 1.60 | 18.50 | 102.20 | 58.50 | 77.50 | 109.00 |
| 13. | NHH 1222 | 1370 | 484 | 35.29 | 3.78 | 8.74 | 4.77 | 29.60 | 1.70 | 21.30 | 96.50 | 56.00 | 76.50 | 108.00 |
| 14. | NHH 1221 | 1193 | 407 | 34.08 | 3.52 | 8.53 | 4.42 | 27.90 | 1.90 | 18.10 | 105.90 | 59.50 | 80.50 | 105.50 |
| 15. | NHH 1215 | 1648 | 626 | 37.99 | 3.96 | 8.54 | 5.22 | 32.00 | 1.90 | 20.70 | 104.30 | 58.50 | 77.00 | 103.50 |
| 16. | NHH 1212 | 1565 | 599 | 37.89 | 3.33 | 8.58 | 5.24 | 29.00 | 1.40 | 20.50 | 101.20 | 57.50 | 78.50 | 104.50 |
| 17. | NHH 1211 | 1533 | 560 | 36.40 | 3.89 | 7.92 | 4.55 | 28.50 | 2.20 | 20.70 | 110.00 | 61.00 | 81.50 | 106.00 |
| 18. | NHH 1204 | **1862**$^*$ | 715$^*$ | 38.51 | 3.65 | 8.29 | 5.17 | 36.80 | 1.40 | 15.70 | 104.80 | 59.50 | 78.50 | 108.00 |
| 19. | NHH 1203 | 1510 | 595 | 39.67 | 3.72 | 8.30 | 5.50 | 31.30 | 1.60 | 19.90 | 95.10 | 59.50 | 82.50 | 103.50 |
| 20. | NHH 1201 | 1333 | 505 | 37.88 | 3.55 | 8.65 | 5.26 | 32.00 | 1.40 | 18.00 | 87.00 | 60.50 | 78.50 | 104.00 |
| 21. | NHH 1200 | 1389 | 564 | 40.60 | 3.95 | 7.21 | 4.92 | 25.30 | 1.30 | 16.40 | 91.40 | 57.50 | 76.00 | 105.50 |
| 22. | NHH 1199 | 1376 | 516 | 37.18 | 2.90 | 6.75 | 4.00 | 22.30 | 1.60 | 16.70 | 97.10 | 59.50 | 78.50 | 106.50 |
| 23. | NHH 1198 | 1101 | 403 | 36.58 | 3.54 | 6.52 | 3.77 | 16.70 | 1.40 | 16.50 | 95.40 | 59.50 | 78.00 | 108.00 |
| 24. | NHH 1189 | 1365 | 496 | 36.55 | 3.30 | 8.38 | 4.79 | 24.70 | 1.60 | 19.60 | 113.90 | 57.50 | 76.00 | 100.00 |
| 25. | NHH 1187 | 826 | 272 | 32.94 | 4.09 | 8.86 | 4.36 | 21.10 | 1.40 | 19.10 | 124.50 | 59.50 | 79.50 | 99.50 |
| 26. | NHH 1178 | 844 | 272 | 32.19 | 2.46 | 7.00 | 3.32 | 20.10 | 1.90 | 19.40 | 105.60 | 60.50 | 77.50 | 103.50 |
| 27. | NHH 1167 | 859 | 281 | 32.79 | 2.83 | 6.84 | 3.35 | 19.50 | 1.90 | 15.50 | 77.10 | 56.00 | 79.50 | 100.50 |
| 28. | NHH 1166 | 764 | 270 | 35.44 | 3.39 | 8.61 | 4.80 | 16.60 | 1.80 | 16.90 | 81.90 | 59.50 | 81.50 | 101.00 |
| 29. | NHH 1165 | **1832**$^*$ | 681$^*$ | 37.19 | 4.28 | 8.91 | 5.29 | 42.10 | 1.90 | 20.20 | 101.60 | 57.50 | 81.50 | 100.00 |
| 30. | NHH 1154 | 828 | 288 | 34.75 | 2.58 | 6.96 | 3.71 | 21.40 | 1.00 | 18.50 | 66.80 | 58.00 | 79.50 | 100.00 |
| 31. | NHH 1152 | 686 | 264 | 38.44 | 2.43 | 8.47 | 5.28 | 25.50 | 1.60 | 16.20 | 81.50 | 58.50 | 80.50 | 106.00 |
| 32. | NHH 1139 | 668 | 243 | 36.43 | 2.15 | 9.38 | 5.35 | 29.40 | 1.80 | 14.50 | 86.70 | 60.50 | 79.50 | 108.00 |
| 33. | NHH 1136 | 1201 | 439 | 36.50 | 3.63 | 7.73 | 4.45 | 32.60 | 1.50 | 19.70 | 95.10 | 61.00 | 81.50 | 109.50 |
| 34. | NHH 1117 | 509 | 171 | 33.46 | 3.29 | 7.73 | 3.89 | 25.50 | 0.40 | 12.80 | 94.50 | 61.50 | 79.50 | 110.50 |
| 35. | NHH 1115 | 1310 | 455 | 34.78 | 3.99 | 8.12 | 4.34 | 21.50 | 1.90 | 21.10 | 91.00 | 60.00 | 79.00 | 106.00 |
| 36. | NHH 1111 | 746 | 279 | 37.43 | 3.29 | 7.81 | 4.67 | 25.20 | 1.60 | 16.60 | 86.60 | 57.50 | 78.50 | 106.00 |
| 37. | NHH 1110 | 1069 | 358 | 33.57 | 2.93 | 7.99 | 4.04 | 27.90 | 1.90 | 17.00 | 93.30 | 55.00 | 77.00 | 106.00 |
| 38. | NHH 1109 | 1064 | 396 | 37.52 | 3.33 | 9.25 | 5.54 | 26.50 | 1.90 | 19.10 | 99.30 | 56.00 | 81.50 | 100.00 |
| 39. | NHH 1107 | 818 | 300 | 36.66 | 3.45 | 7.75 | 4.48 | 27.60 | 1.30 | 18.30 | 89.80 | 59.50 | 82.50 | 104.50 |
| 40. | NHH 1104 | 343 | 121 | 35.62 | 2.88 | 8.14 | 4.49 | 27.60 | 0.60 | 13.50 | 72.00 | 55.00 | 83.00 | 102.00 |
| 41. | NHH 1097 | 815 | 283 | 34.71 | 2.83 | 8.05 | 4.28 | 29.20 | 1.00 | 16.80 | 84.60 | 58.00 | 79.50 | 108.00 |
| 42. | NHH 1092 | 1040 | 384 | 36.87 | 3.07 | 7.44 | 4.34 | 28.40 | 1.50 | 17.00 | 87.40 | 61.00 | 81.50 | 107.00 |
| 43. | NHH 1088 | 734 | 267 | 36.42 | 3.61 | 8.40 | 4.81 | 24.20 | 1.00 | 18.30 | 96.60 | 60.00 | 81.50 | 105.50 |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 44. | NHH 1084 | 1112 | 407 | 36.59 | 3.59 | 8.19 | 4.73 | 30.30 | 1.40 | 16.70 | 94.10 | 61.00 | 81.50 | 110.00 |
| 45. | NHH 1081 | 983 | 368 | 37.79 | 3.57 | 8.28 | 5.04 | 27.50 | 1.00 | 18.00 | 92.40 | 58.50 | 79.50 | 108.00 |
| 46. | NHH 1079 | 525 | 198 | 37.64 | 3.63 | 8.28 | 4.99 | 23.90 | 1.00 | 14.80 | 79.70 | 56.50 | 79.50 | 107.50 |
| 47. | NHH 1075 | **1817*** | 642 | 35.31 | 3.41 | 8.33 | 4.59 | 29.80 | 1.60 | 18.90 | 95.90 | 57.00 | 80.50 | 104.50 |
| 48. | NHH 1074 | 797 | 301 | 37.76 | 2.66 | 7.69 | 4.67 | 25.00 | 1.20 | 14.90 | 72.30 | 56.00 | 78.00 | 106.00 |
| 49. | NHH 1069 | 574 | 222 | 38.88 | 2.94 | 8.15 | 5.19 | 29.00 | 1.20 | 14.10 | 80.40 | 58.50 | 79.00 | 102.50 |
| 50. | NHH 1062 | 1124 | 402 | 35.79 | 3.43 | 7.42 | 4.13 | 23.90 | 1.40 | 15.50 | 90.50 | 55.00 | 80.50 | 104.50 |
| | **Checks** | | | | | | | | | | | | | |
| 51. | NH 615 (Variety) | 1331 | 501 | 37.61 | 4.03 | 7.65 | 4.61 | 16.90 | 1.40 | 17.10 | 112.30 | 55.00 | 77.00 | 107.50 |
| 52. | NCS 145 (Hybrid) | 1103 | 388 | 34.99 | 4.15 | 8.93 | 4.85 | 18.50 | 1.70 | 20.00 | 107.40 | 57.00 | 80.50 | 106.50 |
| 53. | NHH 250 (Hybrid) | 1420 | 530 | 37.33 | 3.80 | 8.40 | 5.01 | 23.70 | 1.40 | 18.90 | 113.90 | 54.00 | 80.50 | 108.50 |
| 54. | NHH 44 (Hybrid) | 1338 | 463 | 34.61 | 3.59 | 8.76 | 4.64 | 31.80 | 1.40 | 19.60 | 114.00 | 58.00 | 76.50 | 110.50 |
| | **SE±** | **130** | **49.42** | **1.26** | **0.311** | **0.589** | **0.404** | **3.26** | **0.302** | **1.225** | **7.06** | **0.810** | **0.691** | **0.806** |
| | **CD @ 5%** | **359** | **136.79** | **3.47** | **0.861** | **1.631** | **1.118** | **9.01** | **0.836** | **3.339** | **19.53** | **2.244** | **1.911** | **2.228** |
| | **CV %** | **15.56** | **16.48** | **4.91** | **12.77** | **10.17** | **12.29** | **17.39** | **28.74** | **9.83** | **10.45** | **1.98** | **1.23** | **1.08** |

*Significant over all the checks

Lint index ranged from 3.32 to 5.54 g. Among the hybrids, NHH 1109 (5.54 g) showed the highest value of lint index, while NHH 1178 (3.32 g) showed the lowest value of lint index. The hybrids NHH 1203 (5.50 g), NHH 1225 (5.37) and NHH 1139 (5.35) exhibited higher lint index than standard check, NHH 250 (5.01). The high mean performance for yield and yield contributing characters was also recorded by Ali and Khan (2007); Dhamayanathi *et al.*, (2010); Hussain *et al.*, (2010); Elango *et al.*, (2012); Koli *et al.*, (2014); Baloch *et al.*, (2015); Moghny *et al.*, (2015).

**(c) Performance for fibre quality traits.** Per se performance of different *intra-hirsutum* cotton hybrids in comparison to check varieties and hybrids with respect to fibre quality parameters are presented in Table 3.

Fibre quality traits generally includes fibre length (mm), fibre uniformity (%), fibre strength (g/tex), fibre elongation (%) and micronaire value (µg/inch). Presently, cotton breeding are primarily focussing for genetic improvement of fibre quality traits apart from high yield to fulfil the needs of high speed textile industries. In India, as more than ninety five per cent area is under hybrid cotton, genetic improvement in fibre quality traits of parental lines is more focussed to get substantial heterosis in $F_1$ hybrids. Therefore, there is great challenge to improve the fibre quality and to increase the yield potential simultaneously when planning crossing program by involving parents with diverse genetic background with superior fibre qualities.

As many as six hybrids *viz.*, NHH 1245 (28.2 mm), NHH 1239 (28.6 mm), NHH 1221 (28.0 mm), NHH 1204 (29.1 mm), NHH 1166 (29.2 mm) and NHH 1165 (28.1 mm) recorded better Upper Half Mean Length (mm) compared to varietal check, NH 615 (27.9 mm),whereas none of the hybrid surpass popular hybrid check, NCS 145 (32.1mm). Fibre strength and fibre length are considered as the most important properties affecting yarn quality (Yang, *et al*., 2016). The micronaire value, a measure of fibre fineness, whereas fibre maturity influences the fibre processing and dyeing consistency. Out of fifty test hybrids, fourty hybrids recorded micronaire value comparable to varietal check., NH 615 (4.39 µg/inch) and hybrid checks *viz.*, NCS 145 (4.28 µg/inch), NHH 250 (4.60 µg/inch) and NHH 44 (4.62 µg/inch)., whereas, ten test hybrids depicted poor micronaire values compared to all of the checks (above 5.0 µg/inch). In general, micronaire value around 4.5 µg/inch is desirable coupled with high fibre length and strength. Fibre strength is very important for advanced spinning technologies in the textile industry (Felker, 2001). Almost all the test hybrids depicted Bundle strength at par with varietal check, NH 615 (20.9 g/tex) and hybrid checks *viz.*, NCS 145 (22.7 g/tex), NHH 250 (19.8 g/tex) and NHH 44 (20.0 g/tex). Higher values of fibre elongation is desirable due to high elasticity which helps for continues spinning without any breakage in modern textile industries. Almost all the test hybrids recorded better values for fibre elongation around 6 (%), which was at par with all the checks *viz.*, NH 615 (6.1%), NCS 145 (6.3%), NHH 250 (6.0%) and NHH 44 (6.0%).Fibre maturity is the main factor responsible for quality of raw cotton and substantially impacts on Rep formation as well as further chemical processing. More values of maturity ratio are desirable. All the fibre test hybrids depicted good values of maturity ratio (around 1.0) and were found at par with all the four checks *viz.*, NH 615 (0.99), NCS 145 (0.98), NHH 250 (0.96) and NHH 44 (0.96). Similar results were observed for per cent maturity (%) of fibre in all the test hybrids and checks. Uniformity index (%) is nothing but the ratio between mean length (ML) and upper half quartile length expressed as percentage, more than 85 (%) uniformity index is desirable. All the test hybrids except ten hybrids *viz.*, NHH 1230 (83.6 %), NHH 1225 (83.4 %), NHH 1221 (83.6 %), NHH 1204 (83.4 %), NHH 1167 (81.1 %), NHH 1104 (84.3 %), NHH 1167 (81.1 %), NHH 1097 (84.6 %), NHH 1075 (79.9 %) and NHH 1062 (84.4 %) recorded uniformity index less than 85 (%).Ginning outturn was ranged from

31.75 (NHH 1226) to 40.60 per cent (NHH 1200) amongst the hybrid under testing. Six hybrids *viz.*, NHH 1240 (39.8 %), NHH 1204 (38.5 %), NHH 1203 (39.67 %), NHH 1200 (40.6 %), NHH 1152 (38.4 %) and NHH 1069 (38.8 %) recorded excellent ginning outturn more than 38.00 per cent and better then all the four checks (34.9 to 37.6 %). The top ranking highest yielding hybrids *viz.*, NHH 1245, NHH 1204 and NHH 1165 also recorded excellent ginning outturn (around 38 %). Present findings were also in agreement with the results of Preetha and Ravendran, (2008); Shinde *et al.*, (2012); Siwach and Sangwan (2014); Patel *et al.*, (2014); Kannan and Saravanan (2015).

**Table 3: Fibre quality parameters of newly developed *intra hirsutum cotton* hybrids of *G. hirsutum* hybrids tested under *rainfed* condition at Cotton Research Station Nanded.**

| Sr. No. | Name of hybrid | UHML (mm) | Micronaire (µg/inch) | Bundle strength (g/tex) | Elongation (%) | Uniformity index (%) | M.R. | Per cent maturity (%) |
|---|---|---|---|---|---|---|---|---|
| 1. | NHH 1245 | 28.2 | 4.80 | 20.7 | 6.1 | 90.9 | 0.97 | 85.0 |
| 2. | NHH 1240 | 26.6 | 4.86 | 21.1 | 6.1 | 90.8 | 0.98 | 86.0 |
| 3. | NHH 1239 | 28.6 | 4.73 | 20.8 | 6.0 | 90.6 | 0.97 | 85.0 |
| 4. | NHH 1238 | 26.2 | 5.42 | 20.4 | 6.2 | 87.4 | 0.95 | 84.0 |
| 5. | NHH 1236 | 27.2 | 4.14 | 21.4 | 6.2 | 92.6 | 0.98 | 86.0 |
| 6. | NHH 1235 | 27.7 | 4.97 | 21.4 | 6.2 | 88.7 | 0.96 | 84.0 |
| 7. | NHH 1232 | 26.4 | 4.35 | 20.3 | 6.0 | 90.2 | 0.98 | 86.0 |
| 8. | NHH 1231 | 27.6 | 5.60 | 20.1 | 6.0 | 87.1 | 0.95 | 84.0 |
| 9. | NHH 1230 | 26.3 | 4.80 | 20.2 | 6.1 | 83.6 | 0.95 | 84.0 |
| 10. | NHH 1229 | 24.5 | 4.87 | 19.1 | 5.9 | 86.3 | 0.98 | 86.0 |
| 11. | NHH 1226 | 26.3 | 5.25 | 20.3 | 6.1 | 88.7 | 0.95 | 84.0 |
| 12. | NHH 1225 | 27.2 | 4.83 | 19.8 | 6.1 | 83.4 | 0.97 | 85.0 |
| 13. | NHH 1222 | 27.2 | 5.16 | 19.5 | 6.0 | 87.1 | 0.96 | 85.0 |
| 14 | NHH 1221 | 28.0 | 4.82 | 20.8 | 6.1 | 83.6 | 0.98 | 86.0 |
| 15. | NHH 1215 | 26.5 | 4.54 | 20.1 | 6.1 | 89.1 | 0.99 | 87.0 |
| 16. | NHH 1212 | 27.9 | 5.63 | 20.0 | 6.1 | 84.7 | 0.96 | 85.0 |
| 17. | NHH 1211 | 26.8 | 4.10 | 19.9 | 6.1 | 79.8 | 0.98 | 86.0 |
| 18. | NHH 1204 | 29.1 | 4.82 | 20.5 | 6.2 | 83.4 | 0.99 | 86.0 |
| 19. | NHH 1203 | 25.2 | 5.11 | 20.2 | 6.2 | 92.2 | 0.95 | 84.0 |
| 20. | NHH 1201 | 25.6 | 4.44 | 20.1 | 6.1 | 85.2 | 0.97 | 86.0 |
| 21. | NHH 1200 | 24.8 | 5.05 | 19.1 | 6.0 | 86.8 | 0.96 | 84.0 |
| 22. | NHH 1199 | 25.9 | 4.87 | 20.7 | 6.2 | 92.3 | 0.96 | 85.0 |
| 23. | NHH 1198 | 26.2 | 2.97 | 20.9 | 6.0 | 85.6 | 1.02 | 89.0 |
| 24. | NHH 1189 | 27.1 | 5.18 | 19.7 | 6.0 | 87.0 | 0.95 | 84.0 |
| 25. | NHH 1187 | 27.1 | 4.99 | 20.4 | 6.2 | 91.8 | 0.97 | 85.0 |
| 26. | NHH 1178 | 25.5 | 3.69 | 20.5 | 6.2 | 89.3 | 0.99 | 87.0 |
| 27. | NHH 1167 | 25.7 | 3.77 | 20.0 | 6.0 | 81.1 | 1.01 | 88.0 |
| 28. | NHH 1166 | 29.2 | 3.80 | 22.0 | 6.2 | 89.2 | 0.98 | 86.0 |
| 29. | NHH 1165 | 28.1 | 4.61 | 21.1 | 6.2 | 89.6 | 0.97 | 85.0 |
| 30. | NHH 1154 | 23.5 | 2.35 | 20.5 | 6.0 | 87.1 | 1.11 | 95.0 |
| 31. | NHH 1152 | 26.4 | 4.91 | 20.0 | 6.1 | 85.1 | 0.96 | 84.0 |
| 32. | NHH 1139 | 25.6 | 4.26 | 22.0 | 6.2 | 94.1 | 1.00 | 87.0 |
| 33. | NHH 1136 | 26.5 | 4.39 | 21.1 | 6.1 | 91.8 | 0.97 | 85.0 |
| 34. | NHH 1117 | 25.7 | 3.60 | 21.5 | 6.1 | 90.3 | 1.05 | 91.0 |
| 35. | NHH 1115 | 25.8 | 3.33 | 20.5 | 6.0 | 85.6 | 1.04 | 90.0 |
| 36. | NHH 1111 | 27.2 | 4.57 | 20.7 | 6.1 | 88.6 | 0.96 | 85.0 |
| 37. | NHH 1110 | 27.0 | 4.17 | 21.8 | 6.2 | 92.1 | 0.98 | 86.0 |
| 38. | NHH 1109 | 26.0 | 4.20 | 21.1 | 6.0 | 90.1 | 0.98 | 86.0 |
| 39. | NHH 1107 | 25.3 | 4.38 | 20.0 | 6.0 | 86.2 | 0.97 | 85.0 |
| 40. | NHH 1104 | 26.1 | 4.99 | 19.9 | 5.9 | 84.3 | 0.95 | 84.0 |
| 41. | NHH 1097 | 26.4 | 4.17 | 20.2 | 6.1 | 84.6 | 0.99 | 87.0 |
| 42. | NHH 1092 | 27.6 | 4.60 | 20.5 | 6.1 | 85.9 | 0.98 | 86.0 |
| 43. | NHH 1088 | 26.1 | 4.88 | 21.0 | 6.0 | 90.1 | 0.98 | 86.0 |
| 44. | NHH 1084 | 26.5 | 3.93 | 20.5 | 6.0 | 90.6 | 0.98 | 86.0 |
| 45. | NHH 1081 | 26.2 | 4.93 | 20.1 | 6.0 | 87.4 | 0.95 | 84.0 |
| 46. | NHH 1079 | 26.2 | 5.12 | 19.3 | 5.9 | 88.1 | 0.95 | 84.0 |
| 47. | NHH 1075 | 27.2 | 4.42 | 19.4 | 5.9 | 79.9 | 0.97 | 85.0 |
| 48. | NHH 1074 | 24.8 | 4.76 | 19.7 | 6.1 | 85.0 | 0.98 | 86.0 |
| 49. | NHH 1069 | 24.4 | 5.18 | 19.0 | 5.9 | 87.5 | 0.97 | 85.0 |
| 50. | NHH 1062 | 26.4 | 4.14 | 20.3 | 6.1 | 84.4 | 0.98 | 86.0 |
| | **Checks** | | | | | | | |
| 51. | NH 615 (Variety) | 27.9 | 4.39 | 20.9 | 6.1 | 90.7 | 0.99 | 86.0 |
| 52. | NCS 145 (Hybrid) | 32.1 | 4.28 | 22.7 | 6.3 | 93.7 | 0.98 | 86.0 |
| 53. | NHH 250 (Hybrid) | 26.0 | 4.60 | 19.8 | 6.0 | 88.5 | 0.96 | 85.0 |
| 54. | NHH 44 (Hybrid) | 26.1 | 4.62 | 20.0 | 6.0 | 84.5 | 0.96 | 85.0 |

**Useful and Standard heterosis for seed cotton yield and Lint yield (kg/ha):**

India is the only country in the world which grows more than 97 per cent area under hybrid cotton that to under *intra-hirsutum* hybrids (*Gossypium hirsutum* L. × *Gossypium hirsutum* L.). More than six hundred commercial cotton hybrids are available in the market, but cotton growing farmers are looking for high yielding cotton hybrids coupled with superior fibre qualities, big boll size, high ginning outturn and tolerance for insect pests and diseases. Therefore, useful or standard heterosis is of more importance than mid parent or better parent heterosis (heterobeltiosis). In Cotton, seed cotton yield and lint yield can be improved significantly through heterosis breeding by selecting high yielding parents with wide genetic variability in crossing program (Naquibullah *et al*., 2000).

Crosses developed by involving desirable parents with good general combining is therefore necessary to find out the high degree of heterotic response for seed cotton yield and lint yield in cotton. In the present investigation, seed cotton yield was ranged from -74.23 (NHH 1104) to 76.48 per cent (NHH 1245). Eleven hybrids recorded heterosis in positive direction, whereas thirty three hybrids recorded negative heterosis over varietal check., NH 615.Twelve hybrids *viz.*, NHH 1245 (76.48 %), NHH 1240 (20.59 %), NHH 1235 (43.50 %), NHH 1230 (22.09 %), NHH 1225 (12.17 %), NHH 1215 (23.82 %), NHH 1212 (17.58 %), NHH 1211(15.18 %), NHH 1204 (39.89 %), NHH 1203 (13.45 %), NHH 1165 (37.64 %) and NHH 1075 (36.51 %) recorded desirable useful heterosis more than ten per cent over varietal check., NH 615 (Table 4). Standard heterosis for seed cotton yield (kg/ha) was ranged from -68.90 (NHH 1104) to 112.96 (NHH 1245) over popular hybrid check, NCS 145. As many as seventeen hybrids recorded more than 20 per cent desirable standard heterosis over hybrid check., NCS 145, whereas twenty-four hybrids recorded standard heterosis in negative direction over check, NCS 145. Heterosis for seed cotton yield was ranged from -78.18 (NHH 1104) to 63.13 per cent (NHH 1245) over highest yielding hybrid check., NHH 250, whereas five hybrids *viz.*, NHH 1245 (63.13 %), NHH 1235 (32.64 %), NHH 1204(29.31 %), NHH 1165 (27.22 %) and NHH 1075(26.18 %) recorded desirable standard heterosis more than twenty per cent while 35 hybrids recorded undesirable standard heterosis in negative direction over check, NHH 250. In case of hybrid check NHH 44, heterosis for seed cotton yield was ranged from -74.36 per cent (NHH 1104) to 75.56 per cent (NHH 1245). Seven hybrids *viz.*, NHH 1245 (75.56 %), NHH 1235 (42.75 %), NHH 1230 (21.45 %), NHH 1215 (23.17 %), NHH 1204 (39.16 %), NHH 1165 (36.92 %) and NHH 1075(35.80 %) depicted desirable standard heterosis more than twenty per cent, whereas 34 hybrids recorded undesirable standard heterosis in negative direction over second highest yielding hybrid check., NHH 44. Presence of heterosis commercial check was reported by Arshad *et al.*, (2001); Solanki *et al.*, (2014); Kencharaddi *et al.*, (2015); Tuteja (2001); Nirania *et al*., (2005); Tuteja *et al*., (2005); Verma *et al*., (2006); Ganapathy and Nadarajan (2008); Kaushik and Shastry (2011); Patil *et al*., (2011); Pushpam *et al*., (2015).

Lint yield (kg/ha) was ranged from 121 kg/ha (NHH 1104) to 892 kg/ha (NHH 1145) amongst the hybrids under testing. The hybrid NHH 1245 recorded highest useful heterosis (78.04 %) followed by NHH 1204 (42.71 %) and NHH 1165 (35.93 %), whereas thirty five hybrids recorded negative hybrids over check variety, NH 615. The range of -68.81 (NHH 1104) to 129.90 per cent (NHH 1245) , -67.74 (NHH 1117) to 68.30 per cent (NHH 1245) and -73.87 (NHH 1104) to 92.66 (NHH 1245) per cent was recorded by hybrids under testing over hybrid checks, *viz.,* NCS 145, NHH 250 and NHH 44 , respectively (Table 5). Seventeen hybrids recorded more than twenty per cent desirable standard heterosis, whereas, twenty two hybrids depicted standard heterosis in negative direction over standard hybrid check, NCS 145. Five and eleven test hybrids recorded more than twenty per cent desirable standard heterosis over hybrid checks *viz.,* NHH 250 and NHH 44, respectively. These results are in agreement with those reported heterosis for seed cotton yield and lint yield by Bankar *et al.*, (2018); Prakashsinh Rathava *et al.*, (2018); Deosarkar *et al.*, (2009); Patel *et al.*, (2014); Pushpam *et al.*, (2015); Sharma *et al*., (2016).

**Table 4: Useful and standard heterosis of newly developed *intra hirsutum* cotton hybrids for seed cotton yield (kg/ha) over varietal check., NH 615 and Hybrid checks, NCS 145, NHH 250 and NHH 44 under rainfed condition at Nanded.**

| Sr. No. | Name of Hybrid | Seed Cotton Yield (kg/ha) | Useful heterosis over varietal Check NH 615 (%) | Standard heterosis over hybrid checks (%) | | |
|---|---|---|---|---|---|---|
| | | | | NCS 145 | NHH 250 | NHH 44 |
| 1. | NHH 1245 | 2349 | 76.48 | 112.96 | 63.13 | 75.56 |
| 2. | NHH 1240 | 1605 | 20.59 | 45.51 | 11.46 | 19.96 |
| 3. | NHH 1239 | 919 | -30.95 | -16.68 | -36.18 | -31.32 |
| 4. | NHH 1238 | 1273 | -4.36 | 15.41 | -11.60 | -4.86 |
| 5. | NHH 1236 | 756 | -43.20 | -31.46 | -47.50 | -43.50 |
| 6. | NHH 1235 | 1910 | 43.50 | 73.16 | 32.64 | 42.75 |
| 7. | NHH 1232 | 1279 | -3.91 | 15.96 | -11.18 | -4.41 |
| 8. | NHH 1231 | 1068 | -19.76 | -3.17 | -25.83 | -20.18 |
| 9. | NHH 1230 | 1625 | 22.09 | 47.33 | 12.85 | 21.45 |
| 10. | NHH 1229 | 1288 | -3.23 | 16.77 | -10.56 | -3.74 |
| 11. | NHH 1226 | 1157 | -13.07 | 4.90 | -19.65 | -13.53 |
| 12. | NHH 1225 | 1493 | 12.17 | 35.36 | 3.68 | 11.58 |
| 13. | NHH 1222 | 1370 | 2.93 | 24.21 | -4.86 | 2.39 |
| 14. | NHH 1221 | 1193 | -10.37 | 8.16 | -17.15 | -10.84 |
| 15. | NHH 1215 | 1648 | 23.82 | 49.41 | 14.44 | 23.17 |
| 16. | NHH 1212 | 1565 | 17.58 | 41.89 | 8.68 | 16.97 |
| 17. | NHH 1211 | 1533 | 15.18 | 38.98 | 6.46 | 14.57 |
| 18. | NHH 1204 | 1862 | 39.89 | 68.81 | 29.31 | 39.16 |
| 19. | NHH 1203 | 1510 | 13.45 | 36.90 | 4.86 | 12.86 |
| 20. | NHH 1201 | 1333 | 0.15 | 20.85 | -7.43 | -0.37 |
| 21. | NHH 1200 | 1389 | 4.36 | 25.93 | -3.54 | 3.81 |
| 22. | NHH 1199 | 1376 | 3.38 | 24.75 | -4.44 | 2.84 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 23. | NHH 1198 | 1101 | -17.28 | -0.18 | -23.54 | -17.71 |
| 24. | NHH 1189 | 1365 | 2.55 | 23.75 | -5.21 | 2.02 |
| 25. | NHH 1187 | 826 | -37.94 | -25.11 | -42.64 | -38.27 |
| 26. | NHH 1178 | 844 | -36.59 | -23.48 | -41.39 | -36.92 |
| 27. | NHH 1167 | 859 | -35.46 | -22.12 | -40.35 | -35.80 |
| 28. | NHH 1166 | 764 | -42.60 | -30.73 | -46.94 | -42.90 |
| 29. | NHH 1165 | 1832 | 37.64 | 66.09 | 27.22 | 36.92 |
| 30. | NHH 1154 | 828 | -37.79 | -24.93 | -42.50 | -38.12 |
| 31. | NHH 1152 | 686 | -48.46 | -37.81 | -52.36 | -48.73 |
| 32. | NHH 1139 | 668 | -49.81 | -39.44 | -53.61 | -50.07 |
| 33. | NHH 1136 | 1201 | -9.77 | 8.88 | -16.60 | -10.24 |
| 34. | NHH 1117 | 509 | -61.76 | -53.85 | -64.65 | -61.96 |
| 35. | NHH 1115 | 1310 | -1.58 | 18.77 | -9.03 | -2.09 |
| 36. | NHH 1111 | 746 | -43.95 | -32.37 | -48.19 | -44.25 |
| 37. | NHH 1110 | 1069 | -19.68 | -3.08 | -25.76 | -20.10 |
| 38. | NHH 1109 | 1064 | -20.06 | -3.54 | -26.11 | -20.48 |
| 39. | NHH 1107 | 818 | -38.54 | -25.84 | -43.19 | -38.86 |
| 40. | NHH 1104 | 343 | -74.23 | -68.90 | -76.18 | -74.36 |
| 41. | NHH 1097 | 815 | -38.77 | -26.11 | -43.40 | -39.09 |
| 42. | NHH 1092 | 1040 | -21.86 | -5.71 | -27.78 | -22.27 |
| 43. | NHH 1088 | 734 | -44.85 | -33.45 | -49.03 | -45.14 |
| 44. | NHH 1084 | 1112 | -16.45 | 0.82 | -22.78 | -16.89 |
| 45. | NHH 1081 | 983 | -26.15 | -10.88 | -31.74 | -26.53 |
| 46. | NHH 1079 | 525 | -60.56 | -52.40 | -63.54 | -60.76 |
| 47. | NHH 1075 | 1817 | 36.51 | 64.73 | 26.18 | 35.80 |
| 48. | NHH 1074 | 797 | -40.12 | -27.74 | -44.65 | -40.43 |
| 49. | NHH 1069 | 574 | -56.87 | -47.96 | -60.14 | -57.10 |
| 50. | NHH 1062 | 1124 | -15.55 | 1.90 | -21.94 | -15.99 |
| | **Range** | **343 to 2349** | **-74.23 to 76.48** | **-68.90 to 112.96** | **-76.18 to 63.13** | **-74.36 to 75.56** |
| | **Checks** | | | | | |
| 51. | NH 615 (Variety) | 1331 | | | | |
| 52. | NCS 145 (Hybrid) | 1103 | | | | |
| 53. | NHH 250 (Hybrid) | 1420 | | | | |
| 54. | NHH 44 (Hybrid) | 1338 | | | | |

**Table 5: Useful and standard heterosis of newly developed *intra hirsutum* cotton hybrids for lint yield (kg/ha) over varietal check., NH 615 and Hybrid checks, NCS 145, NHH 250 and NHH 44 under rainfed condition at Nanded.**

| Sr. No. | Name of Hybrid | Lint Yield (kg/ha) | Useful heterosis over varietal Check NH 615 (%) | Standard heterosis over hybrid checks (%) | | |
|---|---|---|---|---|---|---|
| | | | | NCS 145 | NHH 250 | NHH 44 |
| 1 | NHH 1245 | 892 | 78.04 | 129.90 | 68.30 | 92.66 |
| 2 | NHH 1240 | 641 | 27.94 | 65.21 | 20.94 | 38.44 |
| 3 | NHH 1239 | 316 | -36.93 | -18.56 | -40.38 | -31.75 |
| 4 | NHH 1238 | 434 | -13.37 | 11.86 | -18.11 | -6.26 |
| 5 | NHH 1236 | 252 | -49.70 | -35.05 | -52.45 | -45.57 |
| 6 | NHH 1235 | 669 | 33.53 | 72.42 | 26.23 | 44.49 |
| 7 | NHH 1232 | 457 | -8.78 | 17.78 | -13.77 | -1.30 |
| 8 | NHH 1231 | 391 | -21.96 | 0.77 | -26.23 | -15.55 |
| 9 | NHH 1230 | 555 | 10.78 | 43.04 | 4.72 | 19.87 |
| 10 | NHH 1229 | 461 | -7.98 | 18.81 | -13.02 | -0.43 |
| 11 | NHH 1226 | 366 | -26.95 | -5.67 | -30.94 | -20.95 |
| 12 | NHH 1225 | 549 | 9.58 | 41.49 | 3.58 | 18.57 |
| 13 | NHH 1222 | 484 | -3.39 | 24.74 | -8.68 | 4.54 |
| 14 | NHH 1221 | 407 | -18.76 | 4.90 | -23.21 | -12.10 |
| 15 | NHH 1215 | 626 | 24.95 | 61.34 | 18.11 | 35.21 |
| 16 | NHH 1212 | 599 | 19.56 | 54.38 | 13.02 | 29.37 |
| 17 | NHH 1211 | 560 | 11.78 | 44.33 | 5.66 | 20.95 |
| 18 | NHH 1204 | 715 | 42.71 | 84.28 | 34.91 | 54.43 |
| 19 | NHH 1203 | 595 | 18.76 | 53.35 | 12.26 | 28.51 |
| 20 | NHH 1201 | 505 | 0.80 | 30.15 | -4.72 | 9.07 |
| 21 | NHH 1200 | 564 | 12.57 | 45.36 | 6.42 | 21.81 |
| 22 | NHH 1199 | 516 | 2.99 | 32.99 | -2.64 | 11.45 |
| 23 | NHH 1198 | 403 | -19.56 | 3.87 | -23.96 | -12.96 |
| 24 | NHH 1189 | 496 | -1.00 | 27.84 | -6.42 | 7.13 |
| 25 | NHH 1187 | 272 | -45.71 | -29.90 | -48.68 | -41.25 |
| 26 | NHH 1178 | 272 | -45.71 | -29.90 | -48.68 | -41.25 |
| 27 | NHH 1167 | 281 | -43.91 | -27.58 | -46.98 | -39.31 |
| 28 | NHH 1166 | 270 | -46.11 | -30.41 | -49.06 | -41.68 |
| 29 | NHH 1165 | 681 | 35.93 | 75.52 | 28.49 | 47.08 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 30 | NHH 1154 | 288 | -42.51 | -25.77 | -45.66 | -37.80 |
| 31 | NHH 1152 | 264 | -47.31 | -31.96 | -50.19 | -42.98 |
| 32 | NHH 1139 | 243 | -51.50 | -37.37 | -54.15 | -47.52 |
| 33 | NHH 1136 | 439 | -12.38 | 13.14 | -17.17 | -5.18 |
| 34 | NHH 1117 | 171 | -65.87 | -55.93 | -67.74 | -63.07 |
| 35 | NHH 1115 | 455 | -9.18 | 17.27 | -14.15 | -1.73 |
| 36 | NHH 1111 | 279 | -44.31 | -28.09 | -47.36 | -39.74 |
| 37 | NHH 1110 | 358 | -28.54 | -7.73 | -32.45 | -22.68 |
| 38 | NHH 1109 | 396 | -20.96 | 2.06 | -25.28 | -14.47 |
| 39 | NHH 1107 | 300 | -40.12 | -22.68 | -43.40 | -35.21 |
| 40 | NHH 1104 | 121 | -75.85 | -68.81 | -77.17 | -73.87 |
| 41 | NHH 1097 | 283 | -43.51 | -27.06 | -46.60 | -38.88 |
| 42 | NHH 1092 | 384 | -23.35 | -1.03 | -27.55 | -17.06 |
| 43 | NHH 1088 | 267 | -46.71 | -31.19 | -49.62 | -42.33 |
| 44 | NHH 1084 | 407 | -18.76 | 4.90 | -23.21 | -12.10 |
| 45 | NHH 1081 | 368 | -26.55 | -5.15 | -30.57 | -20.52 |
| 46 | NHH 1079 | 198 | -60.48 | -48.97 | -62.64 | -57.24 |
| 47 | NHH 1075 | 642 | 28.14 | 65.46 | 21.13 | 38.66 |
| 48 | NHH 1074 | 301 | -39.92 | -22.42 | -43.21 | -34.99 |
| 49 | NHH 1069 | 222 | -55.69 | -42.78 | -58.11 | -52.05 |
| 50 | NHH 1062 | 402 | -19.76 | 3.61 | -24.15 | -13.17 |
| | **Range** | **121 to 892** | **-75.82 to 78.04** | **-68.81 to 129.90** | **-77.17 to 68.30** | **-73.87 to 92.66** |
| | **Checks** | | | | | |
| 51 | NH 615 (Variety) | 501 | | | | |
| 52 | NCS 145 (Hybrid) | 388 | | | | |
| 53 | NHH 250 (Hybrid) | 530 | | | | |
| 54 | NHH 44 (Hybrid) | 463 | | | | |

## CONCLUSION

Cotton is among those of few often cross pollinated crop which is accessible to development of homozygous genotypes as varieties as well as amenable for commercial exploitation of heterosis by exploitation of additive as well as non-additive genetic variance (Ranganatha *et al*., 2013). The present study revealed of considerable amount of heterosis for seed cotton yield and lint yield which indicates larger scope for commercial exploitation of heterosis in hybrid breeding of cotton. Based on the above results, the hybrid combinations *viz.*, NHH 1245, NHH 1235, NHH 1204, NHH 1165 and NHH 1075 may be utilized on large scale for commercial exploitation of heterosis in cotton particularly for seed cotton and lint yield. These hybrids may be introduced directly into the market in non Bt version to fulfil the demand of organic cotton cultivators. Simultaneously, parental lines of these hybrids may be converted into BG II version to develop Bt version of these hybrids to meet the needs of non-organic cotton growers which is having more than 95 per cent area in the state of Maharashtra.

**Conflict of Interest**. None.

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