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# COMBINING ABILITY FOR YIELD AND YIELD CONTRIBUTING CHARACTERS OVER ENVIRONMENTS IN INTER AND INTRASPECIFIC CROSSES OF TETRAPLOID COTTON

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**ABSTRACT**
Present study was undertaken to determine the inherent potential of parental stocks to produce high yielding hybrids. For this purpose, 40 intra-*hirsutum* and interspecific cotton hybrids were developed by crossing 10 lines with four testers in a line x tester mating design during *kharif,* 2012. These 40 hybrids along with their 14 parents (10 females and 4 males) and two checks (Bunny and NHH 44) were evaluated during *kharif,* 2013 at three different locations. The intra specific hybrids NH 656 x NH 615, PH 1024 x PH 1009 and PH 1070 x PH 1009 were recorded for highest sca effects and good in *per se* for seed cotton yield and also important yield contributing characters and interspecific hybrids PH 1070 x RHCB 001 and NH 656 x Suvin noticed high sca for fibre properties over the location. The parents PH 1060, PH 1009, PH 1024 and NH 656 were found as best general combiners for seed cotton yield per plant and other important yield contributing characters over the location. As regards fibre quality, the parents Suvin, PH 1070, RHCB 001 and NH 656 were promising for fibre strength and 2.5 per cent span length over the environments.

## INTRODUCTION

Cotton, 'king of apparel fibre' is the premier cash crop in india play a vital role in agriculture, industry, social and monetary affairs of country's economy. Cotton, through cloth, has influenced the culture and civilizations. Cotton plays a major role in India's economy, both in terms of providing employment directly or indirectly to about 60 million people and in terms of production of wealth and earning foreign exchange for the country. Recent emphasis in cotton breeding is on the simultaneous improvement of yield and fibre quality traits to meet the demand of cotton producers and the textile industry (Coyle and Smith, 1997). Several workers like, Pavasia *et al*. (1990), Sexena *et al*. (1998), Panhwar *et al*. (2008) and Kaliyaperumal *et al*. (2010) have reported combining ability and gene action on several traits including yield cotton. Combining ability helps the breeder in selecting the desirable parents and crosses for exploitation of hybrid in breeding programmes. Several studies revealed that in cotton combining ability assists in gathering strong genetic information (Martani, 1964; Ahuja and Tuteja, 2000). Combining ability studies also elucidate the nature and magnitude of gene action involved in the inheritance of seed cotton yield and its related characters, which will be useful to follow segregating material. The choice of parents for hybridization can be made on the basis of combining ability as well as the *per se* performance. Through the *per se* performance is important, the parents selected based on *per se* performance may not produce desirable hybrids in the event of the presence of non-additive gene action. In this context, combining ability effects provide sound basis for parental selection. Line x tester analysis would reveal general combining ability effects of parents and specific combining ability effects of hybrids. The purpose of this study was to determine the general combining ability and specific combining ability effects for yield and yield contributing characters and to choose appropriate parents and hybrids for the investigated traits.

## MATERIALS AND METHODS

Fourteen promising varieties/genotypes were selected as parents on the basis genetic variation for morphological characters and fibre properties. The experimental material consisted of ten female parents belongs to *hirsutum sp.* i.e. PH 348, PH 1024, PH 1075, PH 1060, NH 630, NH 635, NH 656, NH 665, PH 330 and PH 1070 and four male parent *i.e.* PH 1009, NH 615 (two belongs to *hirsutum sp.*), Suvin and RHCB 001 (two belongs to *barbadense sp.*) crossed in a line x tester design at cotton research station, Parbhani during *kharif,* 2012. The conventional hand emasculation and pollination method developed by Dock and Moll (1934) was followed. Forty crosses along with their parents and two checks (Bunny and NHH 44) were evaluated during *kharif,* 2013 at three different locations *viz.,* Cotton Research Station (M. B. Farm), Parbhani ($E_1$), Cotton Research Station, Nanded ($E_2$) and Agricultural Research Station, Badnapur ($E_3$). Each entry was accommodated in two row plot of 6 m length with a spacing of 60 x 60 cm in a randomized block design (RBD) with two replications. Package of practices recommended to the region

were followed. The pooled data were subjected to a line x tester design and combining ability analysis (pooled) and variances were estimated using the model suggested by Kempthorne (1957) related to design II of Comstock and Robinson (1952). Observation were recorded on twelve characters, namely days to 50 per cent flowering, days to maturity, plant height (cm), number of monopodia per plant, number of sympodia per plant, number of bolls per plant, boll weight (g), seed index (g), harvest index (%), 2.5 per cent span length (mm), fibre strength (g/tex) and seed cotton yield per plant (g).

## RESULTS AND DISCUSSION

Analysis of variance (ANOVA) for combining ability (Table 1) revealed significant differences among the environments, treatments, parents and crosses for all the characters under study indicating present considerable genetic diversity over the location. Variance due to parent vs crosses significant for all characters studied except boll weight and number of monopodia per plant over the location. Variance due to lines significant for all characters studied except number of sympodia per plant, boll weight and harvest index over the environment. Variance due to testers significant for all characters studied. Variances due to line x tester significant for all characters studied except number of monopodia per plant over the location. Significance of mean sum of square indicated the presence of sufficient amount of wide genetic diversity or variation among the parents used in hybridization. Analysis of variance for combining ability revealed that both gca and sca variances were important for inheritance of various traits studied. It further suggests the importance of additive and non-additive types of gene action. The sca variances were higher than the gca variances for all the characters indicating preponderance of non-additive gene action in the expression of these characters, this indicates the scope for exploitation of hybrid for the above traits. Predominance of non-additive gene action for cotton yield and its components was also reported by Kaliyaperumal *et al*. (2010), Nidagundi *et al*. (2011), Sahu *et al*. (2013), Dubey *et al*.(2014) and Pushpum *et al*. (2015)

Potentiality of line to be used as parent in hybridization or of cross under used for commercial hybrid may be determined by comparing the *per se* performance of the parent, the $F_1$ value and the combining ability effects. The best three of each parent, $F_1$s, general and specific combiners for twelve quantitative characters presented in table 2, from which it was proved that the estimates of gca effects were correlated with the *per se* performance of the parents may provide a reasonable indication of their gca effects to a certain extent. Among the parents, PH 1060, PH 1009 and PH 1024 were recorded highest general combining ability and also highest *per se* performance for seed cotton yield per plant over three environments (Table 2). These parents with high mean performance and significant *gca* effects could produce trangressive segregants and they can be used in recombination breeding to obtain more favourable gene recombinations for seed cotton yield and associated traits. Good general combining parents have been reported for by Panhwar *et al*. (2008), Dubey *et al*. (2014), and Pushpum *et al*. (2015) among different parents with good general combiners for seed cotton

**Table 1: Pooled analysis of variance for combining ability for various characters over three environments**

| Source of variation | D.F. | Mean sum of squares: Days to 50 flowering % | Days to maturity | Plant height(cm) | No. of monopodia/ plant | No. of sympodia/plant | No. of bolls/plant | Boll weight (g) | Seed index (g) | Harvest index | 2.5 % Span length (mm) | Fibre strength (g/tex) | Seed cotton yield/plant (g) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Replication | 1 | 20.75 | 0.79 | 14.17 | 0.33 | 0.37 | 10.74 | 0.11 | 0.35 | 0.06 | 1.46 | 10.28 | 22.67 |
| Environments | 2 | 378.09** | 1403.61** | 1087.10** | 6.42** | 121.75** | 1273.52** | 0.90** | 8.30** | 182.50** | 19.76** | 30.26** | 7607.10** |
| Treatments | 53 | 234.75** | 548.85** | 1305.61** | 1.10** | 86.84** | 256.61** | 1.54** | 12.42** | 601.51** | 79.76** | 55.75** | 2038.67** |
| Parents | 13 | 209.94** | 541.53** | 366.86** | 0.99** | 22.83** | 161.44** | 2.19** | 7.96** | 48.68** | 45.17** | 64.56** | 1202.17** |
| Crosses | 39 | 228.11** | 552.81** | 1369.11** | 1.15** | 65.70** | 230.73** | 1.35** | 13.76** | 699.92** | 78.06** | 53.15** | 2027.66** |
| Parent vs crosses | 1 | 816.29** | 489.49** | 11032.51** | 0.3 | 1745.23** | 2503.03** | 0.09 | 18.19** | 3950.23** | 595.91** | 42.51** | 13342.18** |
| Lines | 9 | 137.32** | 524.65** | 1450.23* | 1.33* | 46.06 | 280.03* | 1.4 | 12.64** | 106.48 | 64.19* | 44.06* | 2217.04** |
| Testers | 3 | 2358.63** | 4791.49** | 8344.93** | 6.96** | 296.17** | 1210.75** | 5.37** | 115.62** | 8164.58** | 632.10** | 424.14** | 1287.20** |
| Line x Tester | 27 | 21.65** | 91.23** | 566.99** | 0.45 | 46.64** | 105.40** | 0.89** | 2.82** | 68.33** | 21.12** | 14.95** | 759.36** |
| Error | 159 | 9.59 | 31.29 | 25.03 | 0.34 | 2.03 | 9.23 | 0.05 | 0.21 | 5.46 | 2.6 | 2.48 | 50.49 |

*, ** - Significant at 5 per cent and 1 per cent level, respectively

**Table 2: Best three parents, $F_1$ s, general combiner and $F_1$ s showing high sca effect for different characters pooled over three environment .**

| Characters | Sr. No. | Best parent *per se* | Best general combiner in $F_1$ showing high gca | Best $F_1$ s *per se* | $F_1$ s showing high sca |
|---|---|---|---|---|---|
| Days to 50 % flowering | 1 | PH 1024 | PH 1009 | PH 1024 x PH 1009 | PH 1024 x PH 1009 |
| | 2 | PH 1009 | PH 1024 | PH 1060 x PH 1009 | PH 1075 x PH 1009 |
| | 3 | PH 330 | PH 1060 | PH 330 x PH 1009 | PH 330 x PH 1009 |
| Days to maturity | 1 | PH 330 | PH 1009 | PH 1024 x PH 1009 | PH 1024 x PH 1009 |
| | 2 | PH 1024 | PH 1060 | PH 1060 x PH 1009 | NH 665 x NH 615 |
| | 3 | PH 1009 | PH 1024 | PH 330 x PH 1009 | PH 1060 x PH 1009 |
| Plant height (cm) | 1 | RHCB 001 | RHCB 001 | NH 665 x RHCB 001 | NH 656 x NH 615 |
| | 2 | Suvin | PH 1060 | PH 1075 x RHCB 001 | NH 665 x RHCB 001 |
| | 3 | PH 1070 | Suvin | PH 1060 x Suvin | PH 1075 x RHCB 001 |
| No. of monopodia/plant | 1 | NH 656 | PH 1024 | NH 635 x NH 615 | NH 665 x RHCB 001 |
| | 2 | PH 1060 | PH 1009 | PH 1024 x PH 1009 | NH 635 x NH 615 |
| | 3 | NH 630 | NH 615 | PH 330 x PH 1009 | PH 1075 x PH 1009 |
| No. of sympodia/plant | 1 | Suvin | RHCB 001 | NH 665 x RHCB 001 | NH 656 x NH 615 |
| | 2 | RHCB 001 | PH 1060 | PH 1075 x RHCB 001 | NH 665 x RHCB 001 |
| | 3 | PH 1009 | Suvin | NH 635 x RHCB 001 | PH 1070 x PH 1009 |
| No. of bolls/ plant | 1 | PH 1060 | PH 1060 | PH 1060 x PH 1009 | NH 656 x NH 615 |
| | 2 | PH 1009 | PH 1024 | NH 656 x NH 615 | PH 1070 x PH 1009 |
| | 3 | PH 1024 | PH 1009 | PH 1024 x PH 1009 | PH 1024 x PH 1009 |
| Boll weight (g) | 1 | PH 348 | PH 1009 | PH 1024 x PH 1009 | NH 656 x Suvin |
| | 2 | PH 1024 | PH 330 | PH 348 x PH 1009 | NH 630 x RHCB 001 |
| | 3 | PH 1070 | PH 1070 | PH 330 x PH 1009 | PH 1024 x PH 1009 |
| Seed index (g) | 1 | RHCB 001 | RHCB 001 | PH 1075 x RHCB 001 | PH 1070 x NH 615 |
| | 2 | Suvin | PH 1075 | PH 348 x RHCB 001 | NH 665 x NH 615 |
| | 3 | PH 348 | Suvin | PH 1075 x Suvin | PH 1075 x Suvin |
| Harvest index (%) | 1 | PH 1024 | PH 1009 | PH 1024 x PH 1009 | PH 348 x Suvin |
| | 2 | PH 1009 | NH 615 | PH 330 x PH 1009 | PH 330 x PH 1009 |
| | 3 | NH 656 | PH 1024 | NH 635 x PH 1009 | PH 1024 x PH 1009 |
| Span length | 1 | Suvin | Suvin | NH 635 x Suvin | NH 635 x Suvin |
| | 2 | NH 656 | PH 1070 | NH 656 x Suvin | NH 656 x Suvin |
| | 3 | PH 1075 | NH 656 | PH 1070 x Suvin | PH 1070 x Suvin |
| Fibre strength | 1 | Suvin | Suvin | PH 1070 x Suvin | NH 656 x Suvin |
| | 2 | PH 1070 | NH 656 | NH 656 x Suvin | NH 656 x NH 615 |
| | 3 | NH 656 | PH 1070 | PH 330 x Suvin | PH 1070 x Suvin |
| Seed cotton yield/plant (g) | 1 | PH 1060 | PH 1060 | PH 1060 x PH 1009 | NH 656 x NH 615 |
| | 2 | PH 1009 | PH 1009 | PH 1024 x PH 1009 | PH 1024 x PH 1009 |
| | 3 | PH 1024 | PH 1024 | NH 656 x NH 615 | PH 1070 x PH 1009 |

yield and yield contributing characters. The estimates of general combining ability effects over three environments (Table 2) indicated that the parents PH 1009, PH 1024 and PH 1060 were recorded highest general combining ability and also highest *per se* performance for days to 50 per cent flowering and days to maturity. The parents RHCB 001 and PH 1060 were noticed highest general combining ability and RHCB 001 highest *per se* performance for plant height and number of sympodia per plant over the location. For monopodia per plant PH 1024, PH 1009 and NH 615 were best general combiners over the location. Similar findings were admitted by many workers *viz.,* Kaliyaperumal *et al*. (2010), Sahu *et al*. (2013), Dubey *et al*. (2014) and Pushpum *et al*. (2015).

In respect of the parents PH 1060, PH 1024 and PH 1009 were admitted highest general combining ability and also highest *per se* performance for number of bolls per plant over the location. For boll weight the parent PH 1009 followed by PH 330 and PH 1070 showed high gca effect in desirable direction. Moreover the parents RHCB 001, PH 1075 and PH 1070 were good general combiners for seed index over the location whereas; parents PH 1009, NH 615 and PH 1024 were exhibited good gca effect for harvest index. For 2.5 per cent span length the parent Suvin followed by PH 1070 and NH 656 showed high gca effect in desirable direction and also highest *per se* performance over the location. The parents Suvin, NH 656 and PH 1070 were noticed highest general combining ability and also highest *per se* performance for fibre strength over the location. These parents with *per se* performance and significant *gca* effects it would be desirable to have multiple crosses and subject them to selection in segregating generations to detect superior genotypes with high yield and quality traits. Earlier findings like viz., Nidagundi *et al*. (2011) Sahu *et al*. (2013), Dubey *et al*.(2014), and Pushpum et al. (2015) reported different parents with high gca and *per se* performance for yield contributing characters and fibre qualities. The estimates of gca effects showed that the parent PH 1060, PH 1009, PH 1024 and suvin were found best general combiners for seed cotton yield per plant and also for number of bolls per plant, plant height, days to 50 per cent flowering, days to maturity, number of sympodia per plant, harvest index and fibre qualities over the location. The results obtained are in accordance with Panhwar *et al*. (2008), Kaliyaperumal *et al*. (2010), Nidagundi *et al*. (2011), Mendez-Natera *et al*. (2012), Sahu *et al*. (2013), Linghe and pettigre (2015) and Pushpum *et al*. (2015) reported different parents with good general combiners for seed cotton yield and yield

**Table 3: Pooled estimates of general combining ability (gca) effects for various characters over three environments**

| Source of variation | Days to 50 % flowering | Days to maturity | Plant height (cm) | No. of monopodia/plant | No. of sympodia/plant | No. of bolls/plant | Boll weight (g) | Seed index (g) | Harvest index (%) | 2.5 % Span length (mm) | Fibre strength (g/tex) | Seed cotton yield/plant (g) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Line | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| PH 348 | 2.69** | 4.78** | 4.41** | 0.22 | -0.83** | -2.42** | 0.20** | 0.67** | -1.48** | -2.36** | -1.16** | -9.09** |
| PH 1024 | -3.90** | -6.14** | -8.66** | -0.31** | 0.72* | 5.30** | 0.08 | -0.12 | 4.67** | 0.94** | 0.45 | 10.72** |
| PH 1075 | 0.52 | 1.11 | 6.63** | 0.33** | 0.22 | -0.98 | -0.08 | 1.39** | -0.76 | 0.59 | -1.35** | -2.85 |
| PH 1060 | -3.65** | -6.27** | 11.58** | 0.02 | 2.03** | 6.38** | 0.08 | -0.74** | -0.57 | 1.18** | 1.01** | 17.13** |
| NH 630 | 1.44* | 4.07** | -12.13** | 0 | -3.08** | -5.45** | -0.39** | 0.26** | -1.35** | -1.59** | -2.29** | -14.05** |
| NH 635 | 0.81 | 4.53** | -2.01* | -0.14 | 0.77* | 2.79** | -0.02 | -0.27** | 1.92** | -0.57 | -0.04 | 8.04** |
| NH 656 | -0.31 | -1.14 | -6.68** | -0.12 | 0.25 | 2.31** | -0.10* | -0.71** | 1.04* | 1.82** | 2.13** | 4.84** |
| NH 665 | 3.44** | 5.69** | 6.80** | -0.16 | 0.52 | -2.97** | -0.35** | -0.48** | -2.84** | -2.14** | -0.69* | -11.02 |
| PH 330 | -0.94 | -4.56** | -3.81** | -0.22 | 0.51 | -1.80** | 0.38** | -0.69** | 2.04** | -0.06 | 0.86** | -1.1 |
| PH 1070 | -0.1 | 2.06* | 3.87** | 0.38** | -1.09** | 1.47* | 0.21** | 0.68** | -0.63 | 2.47** | 1.08** | 5.80** |
| S.E. (gj) ± | 0.6 | 0.92 | 0.99 | 0.11 | 0.3 | 0.66 | 0.04 | 0.08 | 0.61 | 0.32 | 0.3 | 1.52 |
| Tester | | | | | | | | | | | | |
| RHCB 001 | 6.41** | 9.38** | 13.21** | 0.49** | 2.08** | -5.90** | -0.32** | 1.55** | -10.99** | 1.78** | -0.18 | -18.81** |
| Suvin | 4.06** | 5.38** | 7.60** | -0.03 | 1.49** | 0.25 | -0.02 | 0.79** | -9.01** | 4.26** | 3.70** | -0.7 |
| NH 615 | -3.59** | -4.78** | -11.11** | -0.22** | -2.76** | 1.90** | -0.06* | -1.28** | 8.27** | -2.72** | -2.57** | 2.72** |
| PH 1009 | -6.89** | -9.98** | -8.70** | -0.24** | -0.80** | 5.03** | 0.40** | -1.06** | 11.74** | -2.33** | -0.95** | 16.79** |
| S.E. (gi) ± | 0.38 | 0.58 | 0.63 | 0.07 | 0.19 | 0.42 | 0.03 | 0.05 | 0.39 | 0.2 | 0.19 | 0.96 |

*, ** - Significant at 5 per cent and 1 per cent level, respectively

**Table 4: Estimates of specific combining ability (sca) effects for various characters pooled over three environments**

| Sr. No. | Crosses | Days to 50 % flo wering | Days to maturity | Plant height (cm) | No. of Monopodia / plant | No. of Sympodia/ plant | No. of bolls/ plant | Bolls weight (g) | Seed index (g) | Harvest ) index (% | 2.5 % Span Length (mm) | Fibre Strength (g/tex) | Seed cotton yield/plant (g) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| 1 | PH 348 x RHCB 001 | 1.13 | 0.74 | 7.33** | 0.04 | 0.67 | 3.77** | -0.09 | 0.62** | -1.63 | 2.52** | 1.50* | 10.44** |
| 2 | PH 348 x Suvin | 0.31 | -4.09* | -3.89 | -0.08 | 0.23 | 0.35 | 0.01 | 0.3 | 7.40** | -3.06** | -0.12 | 2.81 |
| 3 | PH 348 x NH 615 | -1.2 | 2.41 | -8.45** | 0.12 | -1.35* | -4.53** | -0.16 | -0.13 | -0.86 | -0.89 | -0.78 | -15.02** |
| 4 | PH 348 x PH 1009 | -0.24 | 2.94 | 5.01* | -0.09 | 0.45 | 0.41 | 0.24** | -0.78** | -4.90** | 1.43* | -0.6 | -11.78** |
| 5 | PH 1024 x RHCB 001 | -1.29 | 2.66 | 0.23 | -0.06 | -3.68** | -3.74** | -0.45** | 0.08 | 1.65 | 0.32 | 0.09 | -11.19** |
| 6 | PH 1024 x Suvin | -0.77 | 0.16 | -9.09** | -0.12 | -0.56 | -3.72** | -0.34** | -0.27 | -3.93 | 0.01 | -1.79** | -14.31** |
| 7 | PH 1024 x NH 615 | 2.38 | -0.84 | 4.62* | 0.28 | 1 | 3.06* | 0.32** | 0.34* | 1.37 | -1.09 | -1.19* | 11.71** |
| 8 | PH 1024 x PH 1009 | -4.32** | -10.68** | 4.24* | -0.1 | 3.23** | 5.02** | 0.47** | -0.15 | 4.62** | 0.77 | 2.89** | 16.95** |
| 9 | PH 1075 x RHCB 001 | 1.3 | 1.24 | 12.11** | 0.01 | 3.52** | 0.76 | 0.30** | -0.08 | -3.12** | 1.46* | 0.88 | 4.05 |
| 10 | PH 1075 x Suvin | -1.52 | -0.26 | 1.16 | 0.18 | -1.32* | -1.82 | -0.24** | 0.94** | -0.3 | 0.41 | -0.53 | -6.70* |
| 11 | PH 1075 x NH 615 | 1.3 | 3.91* | -10.86** | 0.11 | -1.01 | 1.26 | -0.14 | -0.31 | 0.37 | -0.84 | 0.07 | 3.11 |
| 12 | PH 1075 x PH 1009 | -4.07** | -4.89** | -0.41 | -0.3 | -1.20* | -0.2 | 0.07 | -0.24 | 3.05** | -1.03 | -0.42 | -0.46 |
| 13 | PH 1060 x RHCB 001 | -0.04 | 2.78 | -1.21 | 0.21 | -3.43** | -2.53 | -0.60** | 0.59** | 2.34** | 1.27* | -1.50* | -1.4 |
| 14 | PH 1060 x Suvin | -1.69 | -1.22 | 8.98** | 0.22 | 0.89 | -1.75 | 0.24** | -0.12 | -3.11** | -1.18 | 2.60** | -3.74 |
| 15 | PH 1060 x NH 615 | 0.3 | -1.38 | -7.75** | -0.28 | 1.65** | 1.14 | 0.16 | -0.32* | 4.32** | 1.22 | 2.25** | 1.8 |
| 16 | PH 1060 x PH 1009 | -2.63* | -5.18** | -0.03 | -0.16 | 1.88** | 3.14* | 0.20* | -0.16 | -3.54** | -1.31* | -0.57 | 7.34* |
| 17 | NH 630 x RHCB 001 | 1.38 | -3.22 | -5.70** | -0.04 | -2.18** | -0.3 | 0.51** | 0.93** | 0.02 | -0.96 | -1.01 | -0.68 |
| 18 | NH 630 x Suvin | 3.90** | 6.22** | -4.41* | -0.23 | 3.38** | 2.15 | 0.03 | 0.38* | 0.07 | 0.66 | 0.68 | 6.92* |
| 19 | NH 630 x NH 615 | -1.62 | 6.28** | 6.63** | 0.17 | 0.2 | -2.53 | -0.1 | -0.2 | 0.31 | -0.16 | -0.19 | -8.25** |
| 20 | NH 630 x PH 1009 | -0.65 | -2.85 | 3.48 | 0.09 | -0.3 | 0.67 | -0.44** | -0.51** | -0.39 | 0.46 | 0.52 | 2.01 |

**Table 4: Contd....**

| Sr. No. | Crosses | Days to 50 % flowering 1 | Days to maturity 2 | Plant height (cm) 3 | No. of Monopodia/ plant 4 | No. of Sympodia / plant 5 | No. of bolls/ plant 6 | Bolls weight (g) 7 | Seed index (g) 8 | Harvest index (%) 9 | 2.5 % Span Length (mm) 10 | Fibre Strength (g/tex) 11 | Seed cotton yield/plant (g) 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 21 | NH 635 x RHCB 001 | 3.17** | 3.01* | -1.22 | -0.06 | 1.97** | 2.5 | 0.21* | 0.31 | -1.55 | -5.38** | 0.64 | 9.82** |
| 22 | NH 635 x Suvin | -0.65 | -1.68 | -1.37 | 0.52* | 1.26* | -1.49 | 0.1 | 0.88** | -2.36** | 3.32** | -0.27 | -2.29 |
| 23 | NH 635 x NH 615 | -1 | 1.99 | 2.17 | -0.35 | -1.55* | 0.23 | -0.46** | -1.40** | 2.09* | 1.91** | -0.24 | -1.01 |
| 24 | NH 635 x PH 1009 | 0.47 | 0.69 | 0.42 | -0.1 | -1.68** | -1.23 | 0.14 | 0.21 | 3.21** | 0.14 | -0.13 | -6.52* |
| 25 | NH 656 x RHCB 001 | -0.7 | -3.51 | -9.51** | 0.09 | -0.41 | -1.35 | 0.11 | 0.41* | 1.63 | -1.33* | -1.59** | -9.64** |
| 26 | NH 656 x Suvin | 2.31 | 4.16* | -11.96** | -0.03 | -0.72 | 3.98** | 0.52** | -0.36* | 1.01 | 3.06** | 3.46** | 11.75** |
| 27 | NH 656 x NH 615 | -1.2 | 1.49 | 22.91** | -0.17 | 5.23** | 9.31** | 0.44** | -0.41* | -0.9 | 1.93** | 3.23** | 22.80** |
| 28 | NH 656 x PH 1009 | -0.4 | -2.14 | -1.44 | 0.12 | -4.10** | -11.62** | -1.07** | 0.36* | -1.74* | -0.75 | -2.09** | -24.25** |
| 29 | NH 665 x RHCB 001 | 1.9 | 1.16 | 13.95** | -0.61** | 4.88** | -0.45 | 0.04 | -0.63** | -1.98* | 1.59* | 2.83** | -1.39 |
| 30 | NH 665 x Suvin | 4.38** | 7.83** | 11.93** | -0.1 | 1.27* | 0.84 | -0.15 | -0.89** | 1.82* | 0.61 | -0.72 | -5.24 |
| 31 | NH 665 x NH 615 | -3.45** | -5.98** | -13.96** | 0.23 | -2.61** | 0.02 | -0.1 | 0.95** | -0.9 | -1.54* | -2.72** | 5.06 |
| 32 | NH 665 x PH 1009 | -0.82 | 7.69** | -11.91** | 0.49* | -3.54** | -0.41 | 0.21* | 0.57** | -0.33 | -0.66 | -0.4 | 1.58 |
| 33 | PH 330 x RHCB 001 | -2.58* | 0.41 | 1.05 | 0.45 | 1.17 | 0.95 | 0.18* | -0.93** | 0.92 | 1.11 | -0.05 | -1.23 |
| 34 | PH 330 x Suvin | 1.1 | 0.91 | 1.2 | -0.17 | -2.51** | -3.06* | -0.26** | 0.31 | -3.35** | -0.04 | 0.73 | -4.02 |
| 35 | PH 330 x NH 615 | 2.42* | -1.26 | 2.65 | -0.14 | -0.49 | -0.85 | 0.06 | 0.36* | -6.16** | -0.09 | -0.13 | 0.48 |
| 36 | PH 330 x PH 1009 | -3.95** | -4.26* | -4.90* | -0.15 | 1.84** | 2.96* | 0.02 | 0.26 | 4.89** | -0.98 | -0.55 | 4.78 |
| 37 | PH 1070 x RHCB 001 | -2.45* | -1.26 | -15.03** | -0.01 | -2.53** | 0.38 | -0.22* | 0.70** | -1.97** | -0.59 | -1.80** | 1.23 |
| 38 | PH 1070 x Suvin | -1.9 | 2.41 | 7.45** | -0.2 | -0.81 | 4.83** | 0.09 | -0.87** | 1.37 | 2.89** | 2.90** | 14.85** |
| 39 | PH 1070 x NH 615 | 3.29** | 6.93** | 2.03 | 0.03 | -1.06 | -7.09** | -0.03 | 1.13** | 0.37 | -0.46 | -1.29* | -20.03** |
| 40 | PH 1070 x PH 1009 | 2.55* | 0.78 | 5.55** | 0.19 | 4.41** | 5.88** | 0.21* | 0.45** | 0.23 | 1.93** | 1.35* | 15.79** |
| | S.E. | 1.21 | 1.83 | 1.99 | 0.23 | 0.6 | 1.31 | 0.09 | 0.16 | 0.87 | 0.63 | 0.6 | 3.05 |
| | CD@5% | 2.39 | 3.63 | 3.93 | 0.45 | 1.19 | 2.6 | 0.17 | 0.31 | 1.72 | 1.25 | 1.18 | 6.03 |

***, ** significant at 5 per cent and 1 per cent level, respectiely.**

contributing characters.

The best criteria for evaluating the hybrids are based on *per se* performance. However, *sca* effects, and hybrid vigour of the crosses are also considered frequently in cases where a non-additive component of genetic variance predominate the inheritance. The superior hybrids were selected based on high *per se* performance, *sca* effects and heterosis for each of a trait. In the present study, out of forty hybrids, the intra-*hirsutum* hybrid NH 656 x NH 615 recorded highest positive significant sca effect followed by the PH 1024 x PH 1009 and PH 1070 x PH 1009 for seed cotton yield per plant over the location. Among these, hybrids *viz*., PH 1024 x PH 1009 ranked second in gca and for *per se* performance and NH 656 x NH 615 ranked first in gca and third for *per se* performance and PH 1070 x PH 1009 ranked third in gca and fourth for *per se* performance (Table 2) over the location. In the highest yielding combination PH 1024 x PH 1009 both the parents had high *gca* effects for yield. The other highest yielding combination was PH 1070 x PH 1009 in which only one parent PH 1009 had significant *gca* effects. The hybrids PH 1024 x PH 1009 and PH 1070 x PH 1009 had high significant positive *sca* effect; parents are good general combiners; highest *per se* performance for yield and yield traits. So, in breeding programme, these two hybrids is very much useful for exploit hybrid or combining high yield and associated traits due to non additive variance. For the number of bolls per plant, the intra-*hirsutum* hybrids NH 656 x NH 615, PH 1070 x PH 1009 and PH 1024 x PH 1009 were found best specific combiner over the location. The hybrids PH 1024 x PH 1009 and PH 1070 x PH 1009 had high significant positive *sca* effect; parents are good general combiners; highest *per se* performance this useful exploit hybrid for number of bolls per plant. In case of boll weight, the interspecific cross NH 656 x Suvin exhibited highest positive significant sca effect followed by NH 630 x RHCB 001 and PH 1024 x PH 1009 over the environment. Similar findings were admitted by many workers *viz*., Sahu *et al*. (2013), Dubey *et al*. (2014), Linghe and pettigre (2015) and Pushpum *et al*. (2015).

The highly significant negative sca effect and highest *per se* performance was observed in the intra-*hirsutum* hybrid PH 1024 x PH 1009 for days to 50 per cent flowering and days to maturity over the location. The intra-*hirsutum* cross NH 656 x NH 615 recorded highly significant positive sca effect followed by interspecific crosses NH 665 x RHCB 001 and PH 1075 x RHCB 001 for plant height over the environments. The interspecific cross NH 665 x RHCB 001 expressed highest negative sca effect for monopodia per plant over the location. High positive sca effects for number of sympodia per plant observed in the hybrid NH 656 x NH 615 followed by NH 665 x RHCB 001 and PH 1070 x PH 1009 over the location. Moreover the intra-*hirsutum* hybrids PH 1070 x NH 615 and NH 665 x NH 615 were good specific combiners for seed index over the location. Seed index has positive correlation with seed cotton yield. Whereas, The interspecific cross PH 348 x Suvin followed by the intra-*hirsutum* hybrids PH 330 x PH 1009 and PH 1024 x PH 1009 were noticed positive sca effect for harvest index over the environment. In the present investigation the interspecfic hybrids NH 635 x Suvin recorded the highest sca effect for 2.5 per cent span length over three locations followed by NH 656 x Suvin and PH 1070 x Suvin. The hybrid NH 656 x Suvin, exhibited the highest positive SCA effect for fibre strength followed by NH 656 x NH 615 and PH 1070 x Suvin over the locations. Similar findings were reported by many workers *viz.,* Deosarkar *et al*. (2009), Kaliyaperumal *et al*. (2010), Nidagundi *et al*. (2011) Sahu *et al*. (2013), Dubey *et al*. (2014), Linghe and pettigre (2015) and Pushpum *et al*. (2015). The combining ability of the parents may be considered as reliable guide for prediction of yield potential of a hybrid. Ahuja and Tuteja (2000) also opined that crosses between two high combiners were not always best for specific combining ability.

Analysis for variance for combining ability analysis indicated that the variance due to general combining ability (gca) and specific combining ability (sca) were highly significant for all the characters studied over the location (Table 3 and 4). The estimates of specific combining ability effects over three environments (Table 4) indicated that out of forty hybrids, twelve hybrids showed significant positive specific combining ability effects for plant height, twelve for sympodia per plant, nine for bolls per plant, thirteen for boll weight, fifteen for seed index, nine for harvest index and ten for seed cotton yield per plant. The estimates of specific combining ability effects over three environments (Table 4) indicated that out of forty hybrids, eleven hybrids showed significant positive specific combining ability effects for 2.5 per cent span length and nine for fibre strength. However, seven hybrids for days to 50 per cent were flowering, only one for monopodia per plant and six for days to maturity showed significant negative specific combining ability effects. The results obtained are in accordance with, Nidagundi *et al*. (2011), Mendez-Natera *et al*. (2012), Sahu *et al*. (2013), Dubey *et al*.(2014), Linghe and pettigre (2015) and Pushpum *et al*. (2015)

The data indicated that the females PH 1060 and PH 1024 and male parent PH 1009 and Suvin was a good general combiner for most of yield and yield contributing traits over the location and The intra-*hirsutum* hybrids NH 656 x NH 615, PH 1024 x PH 1009 and PH 1070 x PH 1009 were found to be the best among the 40 hybrids over the location whereas, interspecific hybrids NH 656 x Suvin and PH 1070 x Suvin were found to be the best among over the location. If these crosses were studied in further generation, there is ample scope for developing productive inter and intraspecific hybrids with desirable cross combinations of seed cotton yield and its component characters having superior fibre quality over the location.

## REFERENCES

**Ahuja, S. L and Tuteja, O. P. 2000.** Heterosis and combining ability for yield and its component traits in upland cotton. *J. Cotton Res. Dev.* **14:** 138-142.

**Comstock, R. E. and Robinson, H. F. 1952.** Estimation of average dominance of genes in heterosis. *Lowa State College press. Amer.,* pp. 494-516.

**Coyle, G. G. and Smith, C. W. 1997.** Combining ability for within boll yield components in cotton *Gossypium hirsutum L. Crop Sci.* **37:** 1118-1122.

**Deosarkar, D. B., Jadhav, D. S. and Patil, S. G. 2009.** Combining

ability studies for yield and quality traits in Cotton (*Gossypium hirsutum*). *J. Cotton Res. Dev.* **23(2):** 183-187.

**Dock, I. W. and Moll, R. H. 1934.** A new technique in cotton hybridization suggested changes in existing method of emasculating and bagging cotton flower. *J. Heridity.* **25:** 201-204.

**Dubey, R., Das, A., Ojha, M. D., Saha, B., Ranjan, A. and Singh, P. K. 2014.** Heterosis and combining ability studies for yield and yield contributing traits in brinjal ( Solanum Melongena L.). *The Bioscan.* **9(2):** 889-894.

**Kaliyaperumal, A., Ravikesavan, R. and Prince, K. S. J. 2010.** Combining ability estimates for yield and fibre quality traits in line x tester crosses of upland cotton (*Gossypium hirsutum*). *International J. Bio.* **2(1):** 179-183.

**Kempthorne, O. 1957.** An introduction to genetic statistics. *John. Willey and Sons. Inc*. New York.

**Linghe, Z. and pettigre, W. T. 2015.** Combining ability, heritability, and genotypic correlations for lint yield and fibre quality of upland cotton. *Field Crop Res.* **171:** 176-183.

**Martini, A. 1964.** Heterosis and combining ability for plant height and development data in a diallel cross of two species of cotton. *Crop Sci*. **4:** 265-268.

**Mendez-Natera, J. R., Rondon, A., Hernandez, J. and Merazo-Pinto, J. F. 2012.** Genetic studies in upland cotton (*G. hirsutum* L.) II. General and specific combining ability. *J. Agri. Sci. and Tech.* **14(3):** 617-627.

**Nidagundi, J. M., Deshpande, S. K., Patil, B. R. and Mane, R. S. 2011.** Combining ability and heterosis for yield and fibre quality traits in American cotton. *Crop Improv*. **38(2):** 179-185.

**Panhwar, S. A., Baloch, M. J., Jatoi, W. A., Veesar, N.F. and Majeedano, M. S. 2008.** Combining ability estimates from line x tester mating design in upland cotton. *Proc. Pakistan Acad. Sci.* **45(2):** 69-74.

**Pavasia, M. J., Badaya, S. N., Mehta, N. P. and Kukadia, M. U. 1990.** Genetics of yield, its contributing characters and fibre properties in upland cotton. *ISCI.* **15(2):** 73-79

**Pushpum, R., Thangaraj, K. and Raveendram, T. S. 2015.** Heterosis and combining ability studies in upland cotton for yield characters. *Electronic J. Pl. Breed.* **6(2):** 459-463.

**Sahu, V., Singh, S. K., Sharma, A. and Bhati, P. K. 2013.** Combining ability analysis for yield and yield traits using 'WA' cytoplasm in rice (*Oryza Sativa* L.). *The Bioscan.* **8(3):** 871-874.

**Sexena, U., Saxena, M. K., Acharya, V. N. and Ray, N. 1998.** Combining ability analysis for seed cotton yield and other characters in *G. Arboreum* L. *J. Indian Soc. Cotton Improv.* pp. 137-139.