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*Original Paper*

# Assessment of Gene Action and Combining Ability for Fibre and Yield Contributing Traits in Interspecific and Intraspecific Hybrids of Cotton

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**Abstract**

Munir S., Qureshi M.K., Shahzad A.N., Manzoor H., Shahzad M.A., Aslam K., Athar H. (2018): Assessment of gene action and combining ability for fibre and yield contributing trais in interspecific and intraspecific hybrids of cotton. Czech J. Genet. Plant Breed., 54: 71–77.

Combining ability analysis was performed in order to identify high-yielding genotypes and hybrids. Six lines were crossed with three testers using a line × tester mating design. General combining ability (GCA) of parents, specific combining ability (SCA) of hybrids and gene action for several yield components and fibre were studied in the experiment. Additive gene action was observed in most traits except bolls/plant, sympodia/plant, monopodia/plant, total nodes, seed index, lint/seed, staple strength and seed cotton yield/plant which were influenced by non-additive gene action. GCA revealed that Giza-7 was a good general combiner for staple length, staple strength, seed index, boll weight, bolls/plant and monopodia/plant and BH-167 was good for ginning outturn (GOT) and sympodia/plant. Results of SCA values for hybrids indicated, that the cross Giza-7 × MNH-886 was a superior specific combiner for staple length, monopodia/plant, staple strength and seed cotton yield/plant; CIM-554 × CIM-557 for boll weight, sympodia/plant and lint weight/boll; BH-167 × MNH-886 for GOT and bolls/plant. Selection of such hybrids and good general combiners could be further exploited for yield improvement.

**Keywords**: general combining ability; ginning outturn; line × tester analysis; specific combining ability

Cotton is widely cultivated in tropical and subtropical areas of about sixty countries around the globe (Vineela *et al.* 2013). Fibre yield is the main objective of cotton cultivation (Ashokkumar *et al.* 2010). Selection of the best parents and appropriate crossing plan can assist to develop better hybrids which can enhance yield (Wu *et al.* 2004).

Line × tester analysis evaluates the general combining and specific combining abilities in cross-pollinated crops (Kempthorne 1957) and identifies superior parental genotypes and hybrids in terms of

traits involved in studies (Ahuja & Dhayal 2007). Combining ability also helps in assessing the gene action involved in controlling components of yield. General combining ability (GCA) variances reflect the additive gene action while specific combining ability (SCA) variances reflect the non-additive gene action. It helps in the selection of superior parents to develop superior hybrids and exploits the genetic variability (Inamullah *et al.* 2006). Selection of appropriate parents is essential as genetic variation is required to develop superior varieties with unique genetic

makeup. Variation in fibre and yield traits is affected by the additive and non-additive gene action. GCA variances were lower than SCA variances showing that traits such as bolls/plant, yield, seed index, ginning outturn (GOT) and lint index were controlled by dominant genes (Deshpande & Baig 2003). In some other cases, both additive and dominant gene action controlled the bolls/plant, seed index, GOT; other yield traits (Rokaya *et al.* 2005); fibre yield and fibre elongation traits (Cheatham *et al.* 2003).

The objective of this research was to determine gene action responsible for variation in yield and fibre traits and to determine superior parental genotypes and hybrids.

## MATERIAL AND METHODS

**Plant material and greenhouse cultivation**. Six parental lines Bt.CIM-599, CIM-573, MNH-786, CIM-554, BH-167 belonging to *G. hirsutum* species and GIZA-7 belonging to *G. barbadense* species were crossed in a greenhouse with three testers MNH-886, V4 (exotic cultivar) and CIM-557 belonging to *G. hirsutum* species using the line × tester mating design to develop interspecific and intraspecific hybrids in 2015. Genotypes were selected based on different morphological and yield traits.

**Field layout**. These nine parental genotypes and their eighteen $F_1$ hybrids were evaluated under a field trial in a randomized complete block design using three replications in the fields of Faculty of

Agricultural Sciences and Technology, Bahauddin Zakariya University, Multan, Pakistan during the crop season in 2016. Plant to plant and row to row distance was 30 cm and 75 cm, respectively.

**Data collection and biometrical analysis**. At maturity, data for nineteen traits, i.e. bolls/plant, sympodia/plant, monopodia/plant, node of first fruiting branch (NFB), fruiting nodes, total nodes, boll weight (g), lint weight/boll (LW; g), seeds/boll, lint index (g), ginning outturn (GOT; %), seed index (g), seed cotton/seed (SCS; g), lint/seed (g), seed weight/seed (SWS; g), seed cotton yield/plant (g), micronaire value (μg/inch), staple length (mm) and staple strength (g/tex), from five plants per replication were collected. Lint/seed, SWS and SCS were calculated using Worley *et al.* (1974) method. Fibre traits were determined using a high volume instrument (Uster, Switzerland) at Cotton Research Station, Multan, Pakistan.

Analysis of variance was performed using the method described by Steel *et al.* (1997). Data were further analysed by the Kempthorne (1957) method.

## RESULTS AND DISCUSSION

Significant differences between parents and hybrids were found in all morphological and fibre traits except micronaire value (Table 1), yield and within-boll yield components (Table 2) showing the presence of genetic variability among parental genotypes and their hybrids. Significance of SCA and GCA mean squares showed the involvement of both non-additive and additive

Table 1. Analysis of variance of combining ability in genotypes and their hybrids for morphological and fibre traits in cotton

| SOV | TBP | Mono | Sym | NFB | TN | FN | MIC | SL | SS |
|---|---|---|---|---|---|---|---|---|---|
| Replications | 9.56 | 0.84 | 3.09 | 1.82 | 9.23 | 5.12 | 0.26 | 11.01 | 1.28 |
| Treatments | 81.00** | 2.88** | 68.87** | 6.11** | 74.17** | 1130.84** | 0.34 | 8.21** | 13.81* |
| Parents (P) | 125.45** | 6.08** | 116.62** | 14.21** | 102.95** | 1794.23** | 0.49* | 4.33* | 13.78 |
| P vs C | 356.50** | 8.77** | 61.25** | 5.69* | 60.09** | 1650.00** | 0.13 | 5.63 | 26.85 |
| Crosses | 43.88** | 1.02* | 46.86** | 2.32** | 61.46** | 788.11** | 0.29 | 10.19** | 13.06 |
| GCA (lines) | 113.77** | 1.71* | 97.25** | 5.16** | 88.86** | 1359.64** | 0.55 | 25.34** | 15.43 |
| GCA(testers) | 34.56** | 0.16 | 71.93** | 3.55** | 163.61** | 791.96** | 0.14 | 16.83** | 31.89** |
| SCA (L × T) | 10.81* | 0.85 | 16.64* | 0.65 | 27.33** | 501.58** | 0.19 | 1.28 | 8.11 |
| $\sigma^2$gca | 0.991 | 0.005 | 0.906 | 0.049 | 1.023 | 8.591 | 0.003 | 0.27 | 0.15 |
| $\sigma^2$sca | 1.199 | 0.132 | 3.109 | −0.077 | 6.802 | 6.802 | −0.012 | −0.165 | 0.226 |
| $\sigma^2$gca/$\sigma^2$sca | 0.82 | 0.037 | 0.29 | −0.63 | 0.15 | 1.26 | −0.25 | −1.63 | 0.663 |
| Error | 7.21 | 0.45 | 7.32 | 0.89 | 6.92 | 8.27 | 0.22 | 1.78 | 7.43 |

**Highly significant at α =1%; *significant; SOV – source of variation; Df – degree of freedom; TBP – total bolls/plant; Mono – number of monopodia/plant; Sym – number of sympodia/plant; TN – total nodes; FN – fruiting nodes; MIC – micronaire value; SL – staple length; SS – staple strength; $\sigma^2$gca – general combining ability variance; $\sigma^2$sca – specific combining ability variance

gene action (Table 1 and 2). Estimates of GCA and SCA effects for parents and hybrids on morphological and fibre traits, and within-boll yield components are shown in Table 3 and 4, respectively. GCA values showed Giza-7 was a good general combiner for bolls/plant and fruiting nodes and BH-167 was found superior for sympodia/plant and total nodes. The parental genotype CIM-554 was found better for monopodia/plant and CIM-573 for NFB. The lowest values are desirable in both these traits because although monopodia/plant is a yield-contributing trait but due to insect infestation, a lower number of monopodia/plant is desirable for breeders and the earlier will be the first fruiting node, the higher will be the yield. Hence, negative combining ability is desirable for these traits. For bolls/plant, the cross BH-167 × MNH-886 gave a maximum SCA value (6.18) among intraspecific hybrids and Giza-7 × MNH-886 gave the highest value (5.09) among interspecific hybrids as shown in Figure 1a. Cotton yield can be enhanced utilizing this trait for future hybridization to develop hybrids for economic use. For monopodia/plant, the crosses MNH-786 × V4 (-1.26) and Giza-7× CIM-557 (0.02) gave the lowest values among intraspecific and interspecific hybrids, respectively. CIM-554 × CIM-557 hybrid showed a maximum SCA effect (8.02) on sympodia/plant (Figure1b). SCA values showed that the cross CIM-573 × CIM-557 had values in desirable direction for NFB (-1.15) and total nodes (11.26). For fruiting nodes, maximum SCA effects were found out in Bt.CIM-599 × V4 (Table 3).

Among within-boll yield components, for boll weight, maximum GCA and SCA effects were observed in Giza-7 and in the cross CIM-554 × CIM-557 (Figure 1c). While for seeds/boll, high GCA effects were shown by MNH-786 (2.26) and maximum SCA effects were observed in CIM-573 × CIM-557 (9.40) as shown in Table 4. Regarding the seed index, Giza-7 was found as a superior general combiner and its cross Giza-7 × MNH-886 gave the highest SCA value (3.54). For lint index, the highest GCA effects were estimated in MNH-786 and high SCA effects were observed in Giza-7 × MNH-886. Regarding LW, parental lines Bt.CIM-599 and MNH-786 gave the highest positive GCA effects and the cross CIM-554 × CIM-557 showed a maximum SCA effect (Figure 1d). Figure 1e depicts that BH-167 was a good general combiner and its cross BH-167 × MNH-886 was a good specific combiner for GOT. Giza-7 was a superior general combiner for SCS, SWS and lint/seed and its hybrid Giza-7 × CIM-557 showed the highest SCA values for SCS (0.026) and for lint/seed (0.46). Regarding seed cotton yield/plant, MNH-786 and Giza-7 varieties among parental lines while MNH-886 and CIM-557 varieties among testers showed positive GCA effects. Maximum SCA effects were shown by Giza-7 × MNH-886 (Figure 1f). This cross combination indicated that hybrids superior for yield-contributing components have at least one parent with good general combining ability. Rauf *et al.* (2005) also reported a similar association. But it is not always necessary; some genotypes with poor

Table 2. Analysis of variance of combining ability in genotypes and their hybrids for within-boll yield components and yield in cotton

| SOV | Df | BW | SB | SI | LW | LI | SCS | GOT | LS | SWS | YP |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Replications | 2 | 0.16 | 6.61 | 0.20 | 0.10 | 0.29 | 0.000 025 9 | 21.04 | 1.40 | 0.000 027 1 | 172.5 |
| Treatments | 26 | 0.44** | 37.73** | 4.49** | 0.15** | 0.67** | 0.001 159** | 36.17** | 1.16** | 0.000 443 4** | 1 624. 0** |
| Parents (P) | 8 | 0.47* | 25.64** | 4.41** | 0.16** | 0.97** | 0.000 512 | 47.36** | 1.58** | 0.000 437 5** | 910.8** |
| P vs C | 1 | 4.60** | 325.13** | 0.90 | 0.95** | 0.03 | 0.000 022 | 101.12* | 1.07* | 0.000 098 0 | 17 087.4** |
| Crosses | 17 | 0.18 | 26.51** | 4.74** | 0.095** | 0.55** | 0.001 532** | 27.08** | 0.97** | 0.000 466 5** | 1 050.1** |
| GCA (L) | 5 | 0.17 | 79.44** | 8.73** | 0.19** | 0.40 | 0.002 176 3** | 69.83* | 0.80* | 0.000 848 1** | 1424.0** |
| GCA (T) | 2 | 0.67** | 0.16 | 11.22** | 0.23** | 2.93** | 0.004 801 9** | 25.42 | 4.10** | 0.001 098 4** | 3 327.8** |
| SCA | 10 | 0.08 | 5.31 | 1.45** | 0.02 | 0.16 | 0.000 555 | 6.03 | 0.43 | 0.000 149 2** | 407.5** |
| $\sigma^2$gca | | 0.003 | 0.636 | 0.099 | 0.002 | 0.012 | 0.631 | 0.000 | 0.016 | 0.00 | 19.27 |
| $\sigma^2$sca | | −0.029 | −0.396 | 0.325 | 0.001 | −0.009 | −2.904 | 0.001 | 0.062 | 0.00 | 96.746 |
| $\sigma^2$gca/$\sigma^2$sca | | −0.103 | −1.61 | 0.31 | 2 | 1.33 | −0.21 | 0.1 | 0.26 | 0 | 0.20 |
| Error | 52 | 0.17 | 6.50 | 0.47 | 0.02 | 0.19 | 0.000 278 5 | 14.74 | 0.24 | 0.000 045 5 | 117.3 |

**Highly significant at α =1%; *significant; SOV – source of variation; Df – degree of freedom; BW – boll weight; SB – seeds/boll; SI – seed index; LW – lint weight; LI – lint index; SCS – seed cotton/seed; GOT – ginning outturn; LS – lint/seed; SWS – seed weight/seed; YP – yield/plant; $\sigma^2$gca – general combining ability variance; $\sigma^2$sca – specific combining ability variance

*Original Paper*

*Czech J. Genet. Plant Breed., 54, 2018 (2): 71–77*

GCA values can combine well in order to develop good hybrids, like in case of seeds/boll and GOT. CIM-573 × CIM-557 (5.05) and CIM-554 × CIM-557 (7.15) are superior hybrids with high SCA effects on GOT and seeds/boll, respectively, while their parents have lower GCA effects on these traits (Table 4). Imran *et al.* (2012) also reported superior hybrids developed from parents with lower GCA values.

Regarding the micronaire value, the highest GCA effects were found for BH-167 (0.25). SCA effects were found maximum for CIM-554 × CIM-557 followed by BH-167 × V4. Genotypes having negative GCA effects were considered better because higher GCA values lead to fibre coarseness (Rauf *et al.* 2006). Giza-7 was a good general combiner for fibre length and strength and its hybrid Giza-7 × MNH-886 gave maximum SCA effects on both traits.

The importance of GCA and SCA can be assessed by estimating components of GCA and SCA variances ($\sigma^2$gca and $\sigma^2$sca) and expressing as $\sigma^2$gca/$\sigma^2$sca and if this ratio is closer to 1, it indicates the importance of additive gene action (Baker 1978; Ceyhan *et al.* 2014. Higher magnitude of GCA variances depicted a higher ratio of $\sigma^2$gca/$\sigma^2$sca and vice versa (Shaukat *et al.* 2013). GCA and SCA variances for morphological and fibre traits are shown in Table 1, while Table 2 shows GCA

Table 3. General combining ability and specific combining ability of morphological and fibre traits of cotton in parental genotypes and their hybrids

| Genotypes/hybrids | Mono | NFB | TN | FN | MIC | SL | SS |
|---|---|---|---|---|---|---|---|
| Bt.CIM-599 | −0.19 | −0.57 | −4.37 | 0.36 | 0.15 | −0.50 | −0.08 |
| CIM-573 | 0.29 | −0.85 | 0.07 | −7.64 | 0.06 | −0.55 | −0.43 |
| MNH-786 | −0.12 | −0.44 | 1.11 | 7.29 | −0.29 | −1.26 | 0.26 |
| CIM-554 | −0.45 | 0.34 | 0.30 | 4.92 | 0.17 | −0.80 | −2.10 |
| BH-167 | −0.26 | 0.32 | 4.96 | −19.90 | 0.25 | −0.24 | 0.42 |
| Giza-7 | 0.74 | 1.19 | −2.07 | 14.96 | −0.33 | 3.35 | 1.93 |
| MNH-886 | 0.10 | −0.44 | −1.74 | −7.54 | 0.10 | −0.36 | 1.14 |
| V4 | −0.08 | −0.01 | −1.74 | 2.62 | −0.04 | −0.73 | −1.46 |
| CIM-557 | −0.02 | 0.45 | 3.48 | 4.92 | −0.06 | 1.10 | 0.33 |
| **Intraspecific hybrids** | | | | | | | |
| Bt.CIM-599 × MNH-886 | −0.29 | −0.40 | 1.78 | −22.72 | 0.07 | 0.76 | −0.43 |
| Bt.CIM-599 × V4 | −0.10 | 0.99 | −5.11 | 31.73 | −0.11 | −0.79 | −4.18 |
| Bt.CIM-599 × CIM-557 | −0.47 | 0.86 | −1.37 | 14.69 | 0.27 | 1.92 | 1.20 |
| CIM-573 × MNH-886 | 0.64 | −1.19 | −1.00 | −19.72 | 0.21 | 0.80 | 3.03 |
| CIM-573 × V4 | 0.89 | −0.73 | −8.00 | 12.54 | −0.60 | −0.80 | −2.99 |
| CIM-573 × CIM-557 | −1.00 | −1.15 | 11.26 | 6.91 | 0.17 | −2.86 | −4.97 |
| MNH-786 × MNH-886 | 0.34 | −0.37 | 6.00 | 4.67 | −0.26 | −0.50 | 3.38 |
| MNH-786 × V4 | −1.26 | 0.79 | 4.66 | 17.56 | −0.24 | 0.01 | 2.12 |
| MNH-786 × CIM-557 | 0.82 | 0.16 | 1.07 | −8.25 | −0.17 | 1.22 | −0.08 |
| CIM-554 × MNH-886 | 0.15 | −0.84 | 1.00 | −3.11 | −0.09 | −0.24 | 1.00 |
| CIM-554 × V4 | −0.25 | −0.27 | −5.67 | 23.49 | −0.20 | −0.37 | −2.19 |
| CIM-554 × CIM-557 | −1.03 | 0.31 | 7.59 | −13.48 | 0.81 | −1.92 | −0.97 |
| BH-167 × MNH-886 | −0.05 | 0.72 | 4.22 | −27.18 | 0.33 | −1.03 | 1.72 |
| BH-167 × V4 | −0.31 | 0.55 | 1.67 | −16.06 | 0.42 | −1.72 | −1.94 |
| BH-167 × CIM-557 | −0.34 | 0.20 | 1.74 | −31.22 | 0.27 | 1.06 | 0.74 |
| **Interspecific hybrids** | | | | | | | |
| Giza-7 × MNH-886 | 1.77 | 0.14 | −10.22 | 6.93 | −0.59 | 1.94 | 4.68 |
| Giza-7 × V4 | 0.47 | 0.16 | −13.11 | 29.08 | −0.40 | 1.64 | 0.42 |
| Giza-7× CIM-557 | 0.02 | 0.07 | 3.48 | −5.88 | 0.12 | 0.88 | −0.54 |

Mono – number of monopodia/plant; TN – total nodes; FN – fruiting nodes; MIC – micronaire value; SL – staple length; SS – staple strength; NFB – node of first fruiting branch

and SCA variances for within-boll yield components and yield traits. Non-additive gene action for bolls/plant, sympodia/plant, monopodia/plant, total nodes, seed index, lint/seed, staple strength and seed cotton yield/plant was found due to a higher magnitude of $\sigma^2$sca than $\sigma^2$gca while higher $\sigma^2$gca values than $\sigma^2$sca showed additive gene action for NFB, fruiting nodes, boll weight, seeds/boll, LW, lint index, GOT, SCS, micronaire value and staple length (Table 1 and 2). As bolls/plant are directly associated with seed cotton yield. A higher SCA variance value indicated that non-additive gene action was mainly observed for bolls/plant trait. Therefore, heterosis breeding is suggested to enhance bolls/plant. Several authors also reported

non-additive gene action for bolls/plant (Ahuja & Dhayal 2007), monopodia/plant (Rauf *et al.* 2006), sympodia/plant (Rauf *et al.* 2006), seed index (Zia-ul-Islam *et al.* 2001), lint/seed (Imran *et al.* 2012), seed cotton yield/plant (Karademir *et al.* 2009) and staple strength (Ahuja & Dhayal 2007; Karademir *et al.* 2009). Selection should be delayed for the traits which were controlled by the non-additive gene action until genes were established in later generations (Godoy & Palomo 1999). Additive gene action was also reported for boll weight (Khanzada *et al.* 2008), seeds/boll (Ahmad *et al.* 2001), lint index (Ahuja & Dhayal 2007), GOT (Karademir & Gencer 2010), micronaire value and staple length (Karademir *et*

Table 4. General combining ability and specific combining ability estimates for within-boll yield components of cotton in parental genotypes and their hybrids

| Genotypes/hybrids | SB | SI | LI | SCS | LS | SWS |
|---|---|---|---|---|---|---|
| Bt.CIM-599 | 1.75 | −0.19 | 0.06 | 0.000 | 0.13 | −0.002 |
| CIM-573 | 1.64 | −0.62 | −0.19 | −0.010 | −0.24 | −0.006 |
| MNH-786 | 2.26 | −0.22 | 0.23 | −0.006 | −0.06 | −0.002 |
| CIM-554 | 0.51 | −0.26 | 0.07 | −0.004 | 0.09 | −0.003 |
| BH-167 | −0.43 | −0.68 | −0.32 | −0.010 | −0.38 | −0.007 |
| Giza-7 | −5.73 | 1.96 | 0.15 | 0.031 | 0.46 | 0.019 |
| MNH-886 | −0.11 | 0.45 | 0.22 | 0.005 | 0.24 | 0.005 |
| V4 | 0.04 | −0.91 | −0.47 | −0.018 | −0.55 | −0.009 |
| CIM-557 | 0.07 | 0.46 | 0.25 | 0.014 | 0.31 | 0.004 |
| Intraspecific hybrids | | | | | | |
| Bt.CIM-599 × MNH-886 | 0.10 | 0.05 | 0.13 | 0.006 | 0.13 | 0.000 |
| Bt.CIM-599 × V4 | −0.19 | −0.99 | −0.51 | −0.007 | −0.35 | −0.010 |
| Bt.CIM-599 × CIM-557 | 0.01 | 0.03 | −0.18 | 0.002 | 0.07 | 0.000 |
| CIM-573 × MNH-886 | 0.91 | −0.42 | −0.11 | −0.004 | −0.10 | −0.004 |
| CIM-573 × V4 | 0.59 | −1.17 | −0.50 | −0.017 | −0.68 | −0.012 |
| CIM-573 × CIM-557 | 9.40 | −2.63 | −0.50 | −0.041 | −0.83 | −0.026 |
| MNH-786 × MNH-886 | 0.59 | 1.11 | 0.53 | 0.016 | 0.54 | 0.012 |
| MNH-786 × V4 | 1.15 | 0.84 | 0.38 | 0.013 | 0.37 | 0.008 |
| MNH-786 × CIM-557 | −0.73 | 1.17 | 1.07 | 0.025 | 0.73 | 0.011 |
| CIM-554 × MNH-886 | −0.46 | 0.85 | 0.59 | 0.019 | 0.73 | 0.008 |
| CIM-554 × V4 | 0.37 | 0.18 | 0.26 | 0.009 | 0.38 | 0.002 |
| CIM-554 × CIM-557 | 7.15 | −0.09 | 0.84 | −0.002 | 0.64 | −0.001 |
| BH-167 × MNH-886 | −1.40 | −1.09 | −0.47 | −0.022 | −0.49 | −0.010 |
| BH-167 × V4 | −2.18 | −0.76 | −0.65 | −0.029 | −0.70 | −0.007 |
| BH-167 × CIM-557 | −3.58 | −0.56 | −0.68 | −0.004 | −0.72 | −0.005 |
| Interspecific hybrids | | | | | | |
| Giza-7 × MNH-886 | −7.16 | 3.54 | 0.24 | 0.024 | −0.06 | 0.036 |
| Giza-7 × V4 | −3.14 | 0.33 | −0.24 | −0.016 | −0.45 | 0.003 |
| Giza-7× CIM-557 | −1.44 | −0.39 | −0.20 | 0.026 | 0.78 | −0.004 |

SB – seeds/boll; SI – seed index; LI – lint index; SCS – seed cotton/seed; LS – lint/seed; SWS – seed weight/seed

*Original Paper*

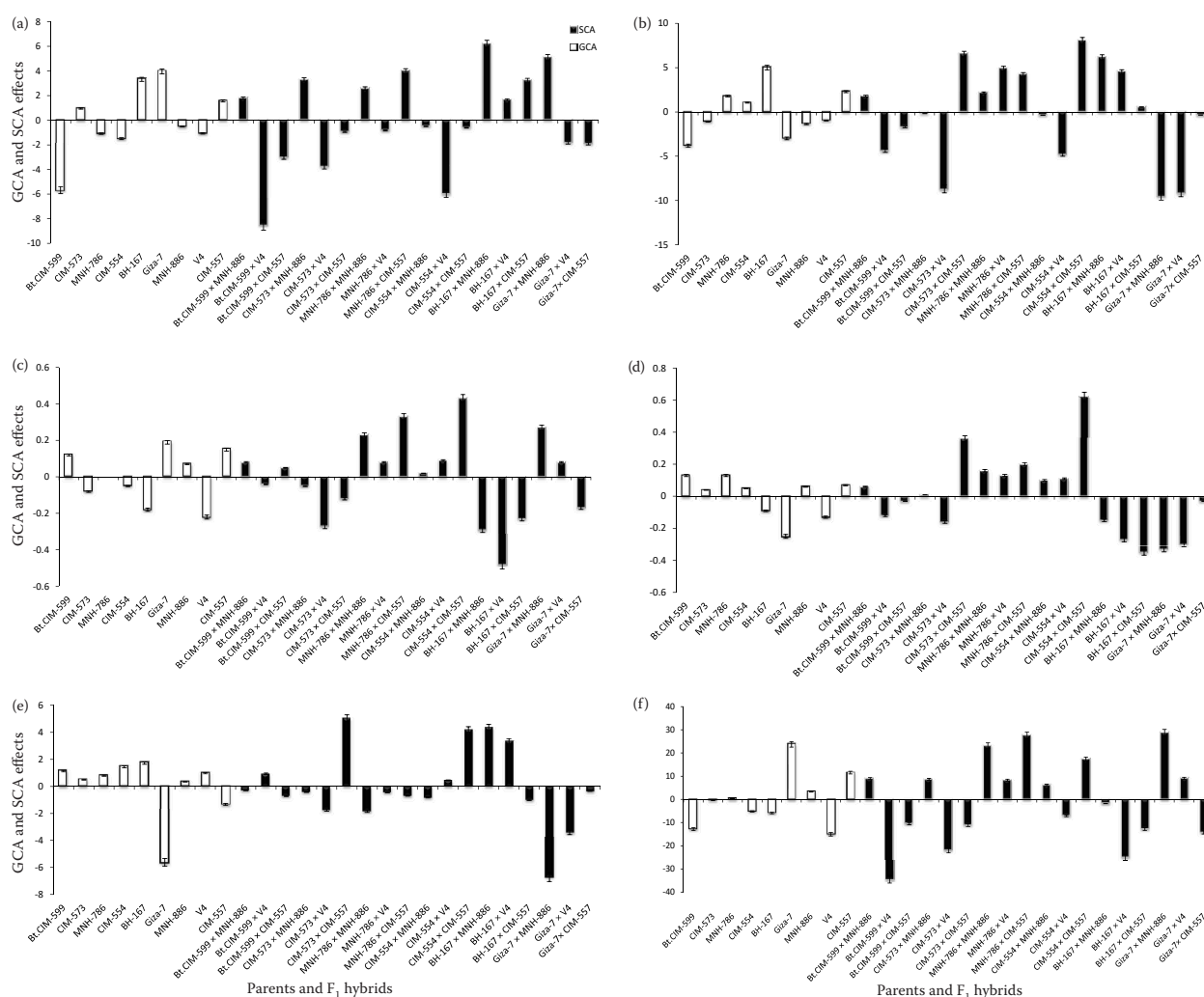*Czech J. Genet. Plant Breed., 54, 2018 (2): 71–77*

Figure 1. Estimates of general combining ability (GCA) and specific combining ability (SCA) for yield and different yield-contributing components in genotypes and their $F_1$ hybrids: estimates for bolls/plant (a), sympodia/plant (b), boll weight (c), lint weight/boll (d), ginning outturn (e), seed cotton yield (f)

$F_1$ – first filial generation; bars in upward direction show positive GCA and SCA values while bars in downward direction show negative GCA and SCA values

*al.* 2009). The presence of transgressive segregants is confirmed by additive gene action in segregating generations (Shaukat *et al.* 2013). Traits controlled by additive gene action mostly have narrow-sense heritability (Kansik & Kapoor 2006). So, selection for these traits can be helpful in an early segregating population (Falconer & MacKay 1996).

## CONCLUSION

Estimation of gene actions can be helpful in future selection of genotypes; as the selection of segregating material can be achieved in earlier generations when additive gene action is significant. While in later generations, selection is more suitable for traits under non-additive gene action. Promising parental varieties (BH-167, Giza-7, CIM-557) and their hybrids (Giza-7 × MNH-886, CIM-554 × CIM-557, BH-167 × MNH-886) can be further exploited to improve the yield and yield related traits.

## References

Ahmad I., Ali A., Zubair M., Khan I.A. (2001): Mode of gene action controlling seed cotton yield and various

components in *Gossypium hirsutum*. Pakistan Journal of Agricultural Sciences, 38: 19–21.

Ahuja S.L., Dhayal L.S. (2007): Combining ability estimates for yield and fiber quality traits in 4 × 13 line × tester crosses of *Gossypium hirsutum*. Euphytica, 153: 87–98.

Ashokkumar K., Ravikesavan R., Silvas K., Prince J. (2010): Combining ability estimates for yield and fiber quality traits in line × tester crosses of upland cotton (*Gossypium hirsutum*). International Journal of Biology, 2: 179–189.

Baker R.J. (1978): Issues in diallel analysis. Crop Science, 18: 533–536.

Cheatham C.L., Jenkin J.N., MacCarty J.C., Watson C.E., Wu J. (2003): Genetic variances and combining ability of crosses of American cultivars, Australian cultivars, and wild cottons. Journal of Cotton Science, 7: 16–22.

Ceyhan E., Harmankaya M., Kahraman A. (2014): Combining ability and heterosis for concentration of mineral elements and protein in common bean (*Phaseolus vulgaris* L.). Turkish Journal of Agriculture and Forestry, 38: 581–590.

Deshpande L.A., Baig K.S. (2003): Combining ability analysis for yield, economic and morphological traits in American cotton (*Gossypium hirsutum* L.). Journal of Research ANGRAU, 31: 28–34.

Falconer D.S., Mackay T.F.C. (1996): Introduction to Quantitative Genetics. 4th Ed. Harlow, Longman Group Limited.

Godoy A.S., Palomo G.A. (1999): Genetic analysis of earliness in upland cotton (*Gossypium hirsutum* L.). I. morphological and phenological variables. Euphytica, 105: 155–160.

Imran M., Shakeel A., Azhar F.M., Farooq J., Saleem M.F., Saeed A., Nazeer W., Riaz M., Naeem M., Javaid A. (2012): Combining ability analysis for within-boll yield components in upland cotton (*Gossypium hirsutum* L.). Genetics and Molecular Research, 11: 2790–2800.

Inamullah, Ahmed H., Muhammad F., Sirajuddin, Hassan G., Gul R. (2006): Evaluation of heterotic and heterobeltiotic potential of wheat genotype for improved yield. Pakistan Journal of Botany, 38: 1159–1168.

Kansik S.K., Kapoor C.J. (2006): Combining ability analysis in upland cotton. National Journal of Plant Improvement, 8: 32–38.

Karademir C., Karademir E., Ekinci R., Gencer O. (2009): Combining ability estimates and heterosis for yield and fiber quality of cotton in line × tester design. Notulae Botanicae Horti Agrobotanici Cluj-Napoca, 37: 228–233.

Karademir E., Gençer O. (2010): Combining ability and heterosis for yield and fiber quality properties in cotton (*G. hirsutum* L.) obtained by half diallel mating design.

Notulae Botanicae Horti Agrobotanici Cluj-Napoca, 38: 222–227.

Kempthorne O. (1957): An Introduction to Genetic Statistics. New York, John Wiley & Sons.

Khanzada S., Baloch M.J., Soomro Z.A., Kumbhar M.B., Khan N.U., Kamboh N., Jatoi W.A., Veesar N.F. (2008): Estimating combining ability through line × tester analysis in upland cotton (*Gossypium hirsutum* L.). Sarhad Journal of Agriculture, 24: 581–586.

Rauf S., Khan T.M., Nazir S. (2005): Combining ability and heterosis in *Gossypium hirsutum* L. International Journal of Agriculture and Biology, 7: 109–113.

Rauf S., Hassan M., Shahzad M.A.B., Ergashev A. (2006): Combining ability analysis in upland cotton (*Gossypium hirsutum*). International Journal of Agriculture and Biology, 8: 341–343.

Rokaya M.H., El-Marakby A.M., El-Agroudy M.H., Seif G.M. (2005): Heterosis and combining ability for fiber-to-seed attachment force, earliness, yield and yield components in a half diallel cross of cotton. Arab Universities Journal of Agricultural Sciences, 13: 741–753.

Shaukat S., Khan T.M., Shakeel A., Ijaz S. (2013): Estimation of best parents and superior cross combinations for yield and fiber quality related traits in upland cotton (*Gossypium hirsutum* L.). Science, Technology and Development, 32: 281–284.

Steel R.G., Torrie J.H., Dickey D.A. (1997): Principles and Procedures of Statistics: A Biological Approach. 3rd Ed. New York, McGraw-Hill.

Vineela N., Murthy J.S.V.S., Ramakumar P.V., Ratna S. (2013): Variability studies for physio morphological and yield components traits in American cotton (*Gossypium hirsutum* L). IOSR Journal of Agriculture and Veterinary Science, 4: 7–10.

Worley S., Culp T.W., Harrel D.C. (1974): The relative contribution of yield components to yield in upland cotton *Gossypium hirsutum*. Euphytica, 23: 399–403.

Wu Y.T., Yin J.M., Guo W.Z., Zhu X.F., Zhang T.Z. (2004): Heterosis performance of yield and fibre quality in $F_1$ and $F_2$ hybrids in upland cotton. Plant Breeding, 123: 285–289.

Zia-ul-Islam H., Sadaqat A., Khan F.A. (2001): Combining ability of some hirsute cotton types for economic traits. International Journal of Agriculture and Biology, 3: 411–412.