

HETEROSIS AND COMBINING ABILITY IN INTRA-SPECIFIC HYBRIDS OF COTTON (*Gossypium hirsutum* L.)

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B.Sc. (Ag.)

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CERTIFICATE

Mr. VIJAY NALLI has satisfactorily prosecuted the course of research and that thesis entitled **“HETEROSIS AND COMBINING ABILITY IN INTRA-SPECIFIC HYBRIDS OF COTTON (*Gossypium hirsutum* L.)”** submitted is the result of original research work and is of sufficiently high standard to warrant its presentation to the examination. I also certify that neither the thesis nor its part thereof has been previously submitted by him for a degree of any University.

Place :

Date :

(V. CHENGA REDDY)

Chairperson

Principal Scientist (Cotton)

RARS, Lam, Guntur

CERTIFICATE

This is to certify that the thesis entitled “**HETEROSIS AND COMBINING ABILITY IN INTRA-SPECIFIC HYBRIDS OF COTTON (*Gossypium hirsutum* L.)**” submitted in partial fulfilment of the requirements for the degree of ‘**Master of Science in Agriculture**’ in the major field of **Genetics and Plant Breeding** of the Acharya N. G. Ranga Agricultural University, Hyderabad is a record of the bonafide original research work carried out by **Mr. VIJAY NALLI** under our guidance and supervision.

No part of the thesis has been submitted by the student for any other degree or diploma. The published part and all assistance received during the course of the investigations have been duly acknowledged by the author of the thesis.

Thesis approved by the student’s advisory committee

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Date of final viva - voce :

DECLARATION

I, **VIJAY NALLI**, hereby declare that the thesis entitled “**HETEROSIS AND COMBINING ABILITY IN INTRA-SPECIFIC HYBRIDS OF COTTON (*Gossypium hirsutum* L.)**” submitted to the **Acharya N.G. Ranga Agricultural University** for the degree of **Master of Science in Agriculture** is the result of original research work done by me. I also declare that no material contained in the thesis has been published earlier in any manner.

Place :

(VIJAY NALLI)
I.D. No. NAM-12-09

Date :

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LIST OF SYMBOLS AND ABBREVIATIONS

%	:	Per cent
ANOVA	:	Analysis of Variance
CD	:	Critical Difference
cm	:	Centimetre
CV	:	Coefficient of variation
d.f	:	Degrees of freedom
<i>et al.</i>	:	and other people
etc.	:	and so on
F ₁	:	First generation hybrid of a cross
g	:	Gram
GA	:	Genetic Advance
GAM	:	Genetic Advance as per cent of Mean
<i>gca</i>	:	General combining ability
GCV	:	Genotypic Co-efficient of Variation
K	:	Potassium
Kg ha ⁻¹	:	Kilograms per hectare
L x T	:	Line x Tester
m	:	Metre
MSL	:	Mean sea level
MSS	:	Mean sum of square
N	:	Nitrogen
NS	:	Non-significant
P	:	Phosphorus
PCV	:	Phenotypic Co-efficient of Variation
<i>per se</i>	:	As such with mean
S	:	Significant
<i>sca</i>	:	Specific combining ability
S.E.	:	Standard error
S.Ed	:	Standard Error of difference
sq. m	:	Square metre
SS	:	Sum of square
via	:	Through
<i>viz.</i> ,	:	Namely
vs.	:	Against

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ABSTRACT

Name of the Author	: VIJAY NALLI
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The present investigation was carried out during *kharif*, 2013-14 at Regional Agricultural Research Station, Lam Farm, Guntur to study the variability, heritability, genetic advance as per cent of mean, combining ability, heterosis, character association and path coefficient analysis for 53 genotypes (40 F₁'s + 13 parents) along with one standard check in cotton for the characters viz., days to 50% flowering, plant height (cm), number of monopodia per plant, number of sympodia per plant, number of bolls per plant, boll weight (g), seed index (g), lint index (g), ginning outturn (%), 2.5% span length (mm), micronaire value (10⁻⁶ g/inch), bundle strength (g/tex), uniformity ratio, lint yield per plant (g) and seed cotton yield per plant (g).

Analysis of variance revealed significant differences among the genotypes for all the characters studied indicating high degree of variability in the material. Wider variability was observed for number of monopodia per plant, number of bolls per plant, boll weight, seed index, seed cotton yield per plant and lint yield per plant. High heritability coupled with high genetic advance as per cent of mean was observed for number of monopodia per plant, boll weight, seed index, seed cotton yield per plant and lint yield per plant.

The character association analysis revealed that plant height, number of sympodia per plant, number of bolls per plant, boll weight, seed index, ginning outturn, micronaire value and lint yield per plant have significant positive association with seed cotton yield per plant both at phenotypic and genotypic levels indicating their importance in direct selection.

The path analysis indicated that plant height, seed index, lint index and lint yield per plant showed direct positive effects and significant correlation with seed cotton yield per plant. Direct selection based on these attributes may be helpful in evolving high yielding varieties of upland cotton.

The analysis of variance for combining ability revealed that lines, crosses and line $\times$ tester effects had significant amount of variability with in each of them for majority of the traits studied. The per cent contribution towards the total variance was maximum due to the interaction of lines and testers for the traits, days to 50% flowering, number of bolls per plant, boll weight, lint index, ginning outturn, 2.5% span length, uniformity ratio, lint yield per plant and seed cotton yield per plant.

The estimates of GCA and SCA variances revealed the predominance of non-additive gene action in the inheritance of number of sympodia per plant, number of bolls per plant, boll weight, lint index, 2.5% span length, ginning outturn, uniformity ratio, lint yield per plant and seed cotton yield per plant, whereas, additive gene action for plant height, number of monopodia per plant and micronaire value.

The *gca* effects of the parents revealed that none of the parent recorded significant *gca* effects for all the characters. The line NDLH 1938 and the tester BS 49 recorded significant general combining ability effects in desirable direction for seed cotton yield per plant and its components. These parents may be utilized as good general combiners in future hybridization programmes aims at improving seed cotton yield along with fibre quality. The hybrids, L 1057 $\times$ BS 49, NDLH 1938 $\times$ GISV 272 and L 762 $\times$ GISV 272 were registered high *sca* effects along with high *per se* performance for seed cotton yield per plant and its contributing traits. The crosses with high $\times$ low, low $\times$ low and high $\times$ high general combiners resulted into hybrids with high *sca* effects. This clearly indicates that one can afford to include some low general combiners also along with good general combiners in hybridization programmes.

Based on overall performance (*per se* performance, *sca* effects and standard heterosis) the crosses viz., L 1057 $\times$ BS 49 and NDLH 1938 $\times$ GISV 272 were found to be promising for seed cotton yield per plant and its components along with few fibre quality traits. These hybrids may be tested over large number of environments for their stability before their release for commercial cultivation.

Chapter I

INTRODUCTION

Cotton (*Gossypium* spp.) is one of the most important commercial crops and is popularly known as “white gold”. It is a precious gift of nature to mankind contributed by the genus *Gossypium* to clothe the people all over the world. It is primarily used in textile industries providing highest employment during production, processing, spinning, weaving and marketing throughout the world. It also occupies the place of pride in Indian agriculture and economy by earning valuable foreign exchange.

India has the distinction of growing all the four spinnable lint bearing species of *Gossypium*, tetraploids ($2n = 4x = 52$) *G. hirsutum* and *G. barbadense* and diploids ($2n = 2x = 26$) *G. arboreum* and *G. herbaceum*. Among the four cultivated species, upland cotton (*G. hirsutum*) is known for its production potential, as demonstrated by the release of number of stable varieties and hybrids.

In India, cotton is being grown in an area of 126.55 lakh ha with an annual production of 400 lakh bales (1 bale=170 kg) with a productivity of 537 kg lint ha⁻¹. In Andhra Pradesh, it occupies an area of about 7.36 lakh ha with an annual production of 21.10 lakh bales and productivity of 624 kg lint ha⁻¹ (AICCIP Annual Report, 2014-15).

Breeding programmes continue to develop new cotton hybrids/varieties to meet the requirements of both producers and consumers. High fiber quality is important for the textile industry since fiber quality directly affects processing performance, productivity and yarn quality. New spinning and weaving technologies in the textile industry mandate that plant breeders and geneticists develop hybrids of cotton with improved fiber quality, especially fiber strength, fiber length and uniformity without sacrificing yield potential.

Selection of parents on the basis of phenotypic performance alone is not a sound procedure, since phenotypically superior lines may yield inferior hybrid or and poor recombinants in the segregating generations. It is, therefore essential that parents should be chosen on the basis of their combining ability.

Combining ability analysis is the most widely used biometrical tool for identifying prospective parents and for formulating breeding procedures that are most likely to succeed. The analysis of general combining ability and specific combining ability helps in identifying potential parents for hybridization and also the production of superior hybrids. The Line $\times$ tester analysis (Kempthorne, 1957) is one of the simplest and efficient methods of evaluating large number of parents for their combining ability. Based on the information from line $\times$ tester analysis, production of commercially viable hybrids is possible. The studies on combining ability are useful for developing efficient methodology for effective genetic improvement in cotton.

The estimates of correlation coefficients mostly indicate the interrelationships of the characters but path analysis permits the understanding of the cause and effect of related characters (Wright, 1921). Path analysis helps in partitioning the total correlations into direct and indirect contribution, thereby suggesting the degree of importance of each of the character towards yield.

Keeping this in view, the present study was undertaken to determine the combining ability effects of 40 hybrids which were obtained by crossing 8 lines with 5 testers in line $\times$ tester fashion along with parents and a check for yield, yield components and fibre quality traits with the following objectives.

1. To assess the genetic parameters (h^2 , GCV, PCV, GAM) of hybrids for yield, yield components and fibre quality traits.
2. To study the type of gene action and combining ability effects in intra-specific hybrids of cotton.
3. To study the heterosis of hybrids and identification of promising high yielding intra-specific hybrids.
4. To study the character association, direct and indirect effects of yield components and fibre quality parameters.

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Chapter III

MATERIAL AND METHODS

The present investigation entitled “**Heterosis and combining ability in intra-specific hybrids of cotton (*Gossypium hirsutum* L.)**” was carried out during *kharif*, 2013-14. The material used and methods followed are presented in this chapter.

3.1 DESCRIPTION OF THE EXPERIMENTAL MATERIAL

The experimental material for this study consisted of 40 intra-specific crosses of cotton along with their 13 parents and one standard check. The crosses were generated by crossing 8 lines with 5 testers in a line × tester fashion (Kempthorne, 1957) during *kharif*, 2012-2013 at Regional Agricultural Research Station, Lam farm, Guntur. The evaluation of these hybrids has been undertaken during *kharif*, 2013-2014. The details of the crosses and their parents used in this study are presented in the Table 3.1.

EXPERIMENTAL SITE LOCATION

The experiment was conducted at RARS, Lam farm, Guntur, Andhra Pradesh which was located at an altitude of 31.5m above MSL, 16°2'N latitude and 80°3'E longitude. The soils were black cotton with clay texture.

3.2 METHODS

3.2.1 Experimental Technique

The details of the experimental techniques followed in the present investigation had been furnished in the Table 3.2.

Table 3.1.The parents, crosses and standard check used in the present study

S.No.	LINES	S.No.	TESTERS
1	L 762	1	CNH 50
2	L 804	2	GISV 272
3	NDLH 1938	3	CNH 44
4	L 1057	4	BS 47
5	L 1060	5	BS 49
6	49 JRP		
7	L 788		
8	L 801		
S.No.	CROSSES		
1	L 762 × CNH 50	21	L 1060 × CNH 50
2	L 762 × GISV 272	22	L 1060 × GISV 272
3	L 762 × CNH 44	23	L 1060 × CNH 44
4	L 762 × BS 47	24	L 1060 × BS 47
5	L 762 × BS 49	25	L 1060 × BS 49
6	L 804 × CNH 50	26	49 JRP × CNH 50
7	L 804 × GISV 272	27	49 JRP × GISV 272
8	L 804 × CNH 44	28	49 JRP × CNH 44
9	L 804 × BS 47	29	49 JRP × BS 47
10	L 804 × BS49	30	49 JRP × BS 49
11	NDLH 1938 × CNH 50	31	L 788 × CNH 50
12	NDLH 1938 × GISV 272	32	L 788 × GISV 272
13	NDLH 1938 × CNH 44	33	L 788 × CNH 44
14	NDLH 1938 × BS 47	34	L 788 × BS 47
15	NDLH 1938 × BS 49	35	L 788 × BS 49
16	L 1057 × CNH 50	36	L 801 × CNH 50
17	L 1057 × GISV 272	37	L 801 × GISV 272
18	L 1057 × CNH 44	38	L 801 × CNH 44
19	L 1057 × BS 47	39	L 801 × BS 47
20	L 1057 × BS 49	40	L 801 × BS 49
S.No.	STANDARD CHECK		
1	LAHH 5		

Table 3.2. Experimental details of heterosis and combining ability in intra-specific hybrids of cotton

Location	RARS Lam, Guntur
Season	<i>kharif</i> , 2013-2014
Experimental design	Randomized Complete Block Design
Entries	54 (8 lines + 5 testers + 40 crosses + 1 standard check)
Replications	3
Number of rows	3
Number of plants per row	10
Row length	6 m
Plot size	1 row of 6 m length
Spacing	105 cm x 60 cm
Fertilizers	120 N: 60 P: 60 K kg/ha
Plant protection	Need based

3.2.2 Record of Observations

Five plants from each genotype in each replication were selected at random and labelled for recording observations. The mean of five plants was used for statistical analysis. For estimating the fibre quality parameters, a composite sample of 250 gm of kapas was obtained from each replication and ginned for seed and lint. The lint sample was used for estimating fibre properties. The data on the following yield and yield component traits and quality parameters were recorded.

3.2.2.1 Days to 50% flowering

The number of days taken by each genotype from sowing to the day when 50 per cent of the plants were seen flowering in the population.

3.2.2.2 Plant height (cm)

Plant height was measured in centimeters from the base of the plant to the apex of the plant at maturity.

3.2.2.3 Number of monopodia per plant

The branches on the main stem which are lateral and axillary in position with vertical growth in acropetal succession were counted at maturity stage avoiding small sprouts.

3.2.2.4 Number of sympodia per plant

Branches which are extra-axillary in position and normally horizontal with zig-zag pattern of fruiting points were taken as sympodia. The number of such sympodia on main stem was counted at maturity stage.

3.2.2.5 Number of bolls per plant

The total number of fully opened bolls harvested from each plant, were counted and averaged.

3.2.2.6 Boll weight (g)

The boll weight in grams was obtained by taking the average weight of seed cotton from randomly collected 20 bolls.

3.2.2.7 Ginning outturn (%)

This is the weight of the lint expressed as percentage of weight of seed cotton calculated according to the following formula

$$\text{Ginning outturn (\%)} = \frac{\text{Weight of lint}}{\text{Weight of seed cotton}} \times 100$$

3.2.2.8 Seed index (g)

It is the absolute weight of 100 seeds recorded in grams.

3.2.2.9 Lint index (g)

It is the absolute weight of lint obtained from 100 seed cotton recorded in grams.

FIBRE PROPERTIES

Based on the availability of sufficient lint for testing, few plants were subjected for detailed investigation for fibre properties. Following characters were analyzed under HVI (High Volume Instrumentation) at Central Institute for Research on Cotton Technology (CIRCOT), Regional Quality Evaluation Unit situated at Lam farm, Guntur, Andhra Pradesh.

3.2.2.10 2.5% span length (mm)

Average length of the fibres expressed as span length was estimated by premier HFT 9000 V 2.1.3 SP high volume instrument in which, the amount of light transmitted through a fibre board is measured in determining the length of the fibre.

3.2.2.11 Micronaire value (10^{-6} g/inch)

A physical property indicating the cross-sectional thickness of fibre, which determines the spinning value of a variety. The fibre fineness was estimated by premier HFT 9000 V 2.1.3 SP high volume instrument.

3.2.2.12 Bundle strength (g/tex)

A measure of the tensile strength of fibre using the principal of constant rate of loading. This was measured by using premier HFT 9000 V 2.1.3 SP high volume instrument.

3.2.2.13 Uniformity ratio

The ratio between 2 span lengths (2.5% and 50%) expressed as a percentage of the longer length was estimated by using premier HFT 9000 V 2.1.3 SP high volume instrument.

3.2.2.14 Lint yield per plant (g)

Total weight of lint obtained from five plants was recorded and averaged.

3.2.2.15 Seed cotton yield per plant (g)

Total weight of seed cotton in grams obtained from five plants was recorded and averaged.

3.3 STATISTICAL ANALYSIS

The data recorded on various characters were subjected to the following statistical analysis.

3.3.1 Analysis of Variance

The Analysis of variance and the significance of genotypic differences were tested for all the characters as per the method given by Panse and Sukhatme (1978).

$$Y_{ij} = \mu + t_i + r_j + e_{ij}$$

Where,

Y_{ij}	=	Performance of i^{th} genotype in j^{th} block
μ	=	General mean
t_i	=	i^{th} genotype effect
r_j	=	j^{th} block effect
e_{ij}	=	Random error

The structural analysis of variance was as follows.

Table 3.3 ANOVA Table for Randomized Block Design

Source of variation	Degrees of freedom	Mean sum of squares	Expected mean sum of squares	“F” calculated value
Replications	(r-1)	M_r	$\sigma_e^2 + g \sigma_r^2$	M_r / M_e
Genotypes	(g-1)	M_g	$\sigma_e^2 + r \sigma_g^2$	M_g / M_e
Error	(r-1) (g-1)	M_e	σ_e^2	
Total	(rg-1)			

Where,

r	=	number of replications
g	=	number of genotypes
M _r	=	replication mean sum of squares
M _g	=	genotype mean sum of squares
M _e	=	error mean sum of squares
σ^2_r	=	variance due to replications
σ^2_g	=	variance due to genotypes
σ^2_e	=	error variance

The test of significance was carried out using 'F' table value of Fisher and Yates (1963).

3.3.2 Estimation of Genetic Parameters

3.3.2.1 Coefficient of variation

The genotypic and phenotypic coefficients of variation were calculated using the formula given by Burton (1952).

a) Genotypic coefficient of variation (GCV)

$$\text{GCV} = \frac{\text{Genotypic standard deviation } (\sigma_g)}{\text{General mean } (\bar{x})} \times 100$$

b) Phenotypic coefficient of variation (PCV)

$$\text{PCV} = \frac{\text{Phenotypic standard deviation } (\sigma_p)}{\text{General mean } (\bar{x})} \times 100$$

Categorization of range of variation was given by Sivasubramaniam and Menon (1973).

Low	=	Less than 10%
Moderate	=	10-20%
High	=	More than 20%

3.3.3 Heritability

Heritability in broad sense ($h^2_{(b)}$) was estimated as per the formula given by Allard (1960).

$$h^2_{(b)} = \frac{\text{Genotypic variance } (\sigma^2_g)}{\text{Phenotypic variance } (\sigma^2_p)} \times 100$$

The range of heritability in broad sense categorization was given by Johnson *et al.* (1955).

Low	=	Less than 30%
Moderate	=	30-60%
High	=	More than 60%

3.3.4 Genetic Advance (GA)

This was estimated as per the formula proposed by Lush (1940) and Johnson *et al.* (1955).

$$G.A = k \times \sigma_p \times h^2_{(b)}$$

Where k = Selection differential at 5% selection intensity which accounts to a constant value of 2.06.

$$h^2_{(b)} = \text{Heritability in broad sense}$$

$$\sigma_p = \text{Phenotypic standard deviation}$$

3.3.5 Genetic Advance as Per cent of Mean (GAM)

Genetic advance was estimated as per cent of mean (GAM) of the population.

$$GAM = \frac{GA}{\bar{x}} \times 100$$

Where,

GA	=	Genetic advance
$\bar{x}$	=	Grand mean

The range of genetic advance as per cent of mean was classified as suggested by Johnson *et al.* (1955)

Low = 10%

Moderate = 10 – 20%

High = >20%

3.3.6 Correlation Studies

Phenotypic and genotypic correlations coefficients between different variables were calculated using covariance technique as per Falconer (1964).

$$\text{Phenotypic coefficients of correlation } (r_p) = r(x_i x_j)_p = \frac{\text{cov}(x_i x_j)_p}{\sqrt{v(x_i)_p \cdot v(x_j)_p}}$$

Where,

$r(x_i x_j)_p$ = Correlation between i^{th} and j^{th} characters

$\text{cov}(x_i x_j)_p$ = Covariance between i^{th} and j^{th} characters

$v(x_i)_p$ = Phenotypic variance of i^{th} character

$v(x_j)_p$ = Phenotypic variance of j^{th} character

$$\text{Genotypic coefficient of correlation } (r_g) = r(x_i x_j)_g = \frac{\text{cov}(x_i x_j)_g}{\sqrt{v(x_i)_g \cdot v(x_j)_g}}$$

Where,

$r(x_i x_j)_g$ = Genotypic correlation between i^{th} and j^{th} character

$\text{cov}(x_i x_j)_g$ = Genotypic covariance between i^{th} and j^{th} character

$v(x_i)_g$ = Genotypic variance of i^{th} character

$v(x_j)_g$ = Genotypic variance of j^{th} character

3.3.6.1 Test of significance

Significance of correlation coefficients was tested by comparing phenotypic correlation coefficients with the table values (Fisher and Yates, 1963) at (n-2) degrees of freedom at 5% and 1% level where 'n' denotes the number of paired observations used in the calculation.

3.3.7 Path Coefficient Analysis

Path coefficient analysis was carried out by using the correlation coefficients to know the direct and indirect effects of the component characters on yield as suggested by Wright (1921) and illustrated by Dewey and Lu (1959).

Path coefficients were obtained by solving the simultaneous equations which express the basic relationship between correlations and path coefficients.

The equations are as follows:

$$\begin{aligned} r_{1y} &= P_{1y} + r_{12}P_{2y} + r_{13}P_{3y} + \dots\dots\dots + r_{1k}r_{1y} \\ r_{2y} &= r_{21}P_{1y} + P_{2y} + r_{23}P_{3y} \dots\dots\dots + r_{2k}P_{ky} \\ \vdots \quad \quad \quad \vdots \quad \quad \quad \vdots \quad \quad \quad \vdots \quad \quad \quad \vdots \quad \quad \quad \vdots \\ r_{ky} &= r_{k1}P_{1y} + r_{k2}P_{2y} + r_{k3}P_{ky} \dots\dots\dots + r_{kk}P_{ky} \end{aligned}$$

Where,

r_{1y} to r_{ky} = Coefficient of correlation between causal factors 1 to k and dependent character y.

r_{12} to r_{k-1} , k = Coefficient of correlation among causal factors

P_{1y} to P_{ky} = Direct effects of characters 1 to k on character y

The residual effect was computed by using the formula

$$R = \sqrt{[1 - (P_{1y}r_{1y} + P_{2y}r_{2y} + P_{3y}r_{3y} + \dots\dots\dots)]}$$

Where,

R = Residual effect

P_{1y} = Direct effect of independent character '1' on dependent character 'y'

r_{1y} = Correlation coefficient of independent character '1' on dependent character 'y'

3.3.8 Combining Ability Analysis

The combining ability analysis of parents and crosses was taken up for different characters using the L x T model as given by Kempthorne (1957).

Mathematical model for combining ability analysis is

$$Y_{ijk} = \mu + g_i + g_j + s_{ij} + r_k + e_{ijk}$$

Where,

Y_{ijk} = any measurable character of the cross i x j in the k^{th} replication

μ = population mean effect

g_i = general combining ability effect of the female parent

g_j = general combining ability effect of the male parent

s_{ij} = specific combining ability effect of (i x j)th cross

r_k = effect due to K^{th} replication

e_{ijk} = environmental effect on (ijk)th individual

Table 3.4. ANOVA of line x tester mating design for combining ability

Source	d.f	MSS	Expected MSS
Replications	r-1	M_r	
Genotypes	(g-1)	M_g	
Parents	(p-1)	M_p	
Crosses	(c-1)	M_{pc}	
Parents vs crosses	1	M_c	
Lines	(l-1)	M_l	$\sigma_p^2 + r\sigma_s^2 + rt\sigma_f^2$
Testers	(t-1)	M_t	$\sigma_p^2 + r\sigma_s^2 + rl\sigma_m^2$
Line x tester	(l-1) (t-1)	M_{lt}	$\sigma_p^2 + r\sigma_s^2$
Error	(r-1) (g-1)	M_e	σ_e^2

Where,

r = number of replications

g = number of genotypes

p = number of parents

c = number of crosses

l = number of lines or female parents

t = number of testers or male parents

c = number of crosses

σ^2_e = random error

σ^2_s = variance of interaction between lines and testers

σ^2_f = variance due to lines

σ^2_m = variance due to testers

3.3.8.1 Estimation of combining ability effects

(i) *gca* effect of line and tester

$$\text{Line } g_i = \frac{x_{j.}}{tr} - \frac{x_{...}}{ltr}$$

$$\text{Tester } g_j = \frac{x_{i.}}{lr} - \frac{x_{...}}{ltr}$$

(ii) *sca* effect of cross

$$s_{ij} = \frac{x_{ij}}{r} - \frac{x_{i.}}{lr} - \frac{x_{.j}}{tr} + \frac{x_{...}}{ltr}$$

Where,

x_i = Total of i^{th} line over all testers and replications

x_j = Total of j^{th} tester over all lines and replications

x_{ij} = X_{ij}^{th} combination total over all replications

x.... = Total of all hybrid combination over all replications

l = number of lines

t = number of testers

r = number of replications

Standard errors for combining ability effects

Standard errors pertaining to *gca* and *sca* effects of different combinations were calculated as follows:

$$S.E\ g_i(\text{lines}) = \sqrt{Me/tr}$$

$$S.E\ g_j(\text{testers}) = \sqrt{Me/lr}$$

$$S.E\ s_{ij}(\text{crosses}) = \sqrt{Me/r}$$

$$S.Ed\ g_i(g_i - g_k)(\text{between } gca \text{ effects of two lines}) = \sqrt{2Me/tr}$$

$$S.E\ g_i(g_j - g_l)(\text{between } gca \text{ effects of two testers}) = \sqrt{2Me/lr}$$

$$S.Eg_i(s_{ij} - g_{kl})(SEd \text{ for any two } sca \text{ effects of hybrids}) = \sqrt{2Me/r}$$

Tests of significance for *gca* and *sca* effects:

The *gca* and *sca* effects were tested against zero for significance by calculation of 't' value by using the following formulae.

$$t\ cal = \frac{g_i - 0}{SE(g_i)}$$

$$t\ cal = \frac{g_j - 0}{SE(g_j)}$$

$$t\ cal = \frac{s_{ij} - 0}{SE(s_{ij})}$$

The 't' values are compared with 't' table value at error degrees of freedom.

3.3.8.2 Estimation of genetic components of variation

Estimation of covariances

Covariance of full-sibs and half-sibs were estimated using the formula as given below.

$$\text{Cov(HS)} = \frac{M_t + M_l - 2M_{lt}}{r(t + l)}$$

$$\text{Cov(FS)} = 1/3r(\{M_t - M_l + M_{lt} - 3M_e + 6r\text{Cov(HS)} - r(t + l)\text{Cov(HS)}\})$$

The genetic components of variation were estimated by relating the variance components to covariance of half sibs (Cov.HS) and full sibs (Cov.FS) as

$$\sigma_f^2 = \sigma_m^2 = \text{Cov. HS}$$

$$\sigma_s^2 = \text{Cov. FS} - 2\text{Cov. HS}$$

$$\sigma_{gca}^2 = \text{Cov. HS} = \left[\frac{1 + F}{4} \right] \sigma_A^2$$

$$\sigma_{sca}^2 = \text{Cov. FS} - \text{Cov. HS} = \left[\frac{1 + F}{4} \right] \sigma_D^2$$

Where,

σ_{gca}^2 = general combining ability variance

σ_{sca}^2 = specific combining ability variance

F = inbreeding coefficient

Proportional contribution of lines, testers and their interactions

$$\text{Percent contribution of lines} = \frac{SS_l}{SS_c} \times 100$$

$$\text{Percent contribution of testers} = \frac{SS_t}{SS_c} \times 100$$

$$\text{Percent contribution of l x t} = \frac{SS_{lt}}{SS_c} \times 100$$

Where,

SS_l = sum of squares of lines

SS_t = sum of squares of testers

SS_{lt} = sum of squares of lines x testers

SS_c = sum of squares of crosses

3.3.9 Estimation of Heterosis

The heterotic effects were measured as deviation of F_1 mean from mid parent (relative heterosis), better parent (heterobeltiosis) and the standard check (standard heterosis) mean as per the following formula given by Liang *et al.* (1971).

The percent of heterosis was calculated as follows;

$$\text{Relative heterosis (\%)} = \frac{\text{Mean of } F_1 - \text{Mean of mid parent}}{\text{Mean of mid parent}} \times 100$$

$$\text{Heterobeltiosis (\%)} = \frac{\text{Mean of } F_1 - \text{Mean of better parent}}{\text{Mean of better parent}} \times 100$$

$$\text{Standard heterosis (\%)} = \frac{\text{Mean of } F_1 - \text{Mean of superior check}}{\text{Mean of superior check}} \times 100$$

3.3.9.1 Test of significance of heterosis

To test the significance of heterosis over mid parent and better parent were used as suggested by Snedecor and Cochran (1967) and Arunachalam (1976).

$$\text{Heterosis 't'} = \frac{\text{Mean of } F_1 - \text{Mean of mid parent(or) better parent}}{\sqrt{2EMS/r}}$$

$$\text{Standard heterosis 't'} = \frac{\text{Mean of } F_1 - \text{Mean of superior check}}{\sqrt{2EMS/r}}$$

The estimated 't' value was compared with 't' table values at respective degrees of freedom.

Chapter IV

RESULTS AND DISCUSSION

The present investigation entitled “Heterosis and combining ability in intra-specific hybrids of cotton (*Gossypium hirsutum* L.)” was carried out with 40 hybrids derived from crossing 8 lines with 5 testers in line x tester fashion and one standard check at Regional Agricultural Research Station, Lam Farm, Guntur during *kharif*, 2013-14.

The data was recorded on plant height (cm), number of monopodia per plant, number of sympodia per plant, number of bolls per plant, boll weight (g), seed index (g), lint index (g), ginning outturn (%), seed cotton yield per plant (g) and lint yield per plant (g) from five randomly selected plants. Whereas days to 50% flowering, 2.5% span length (mm), micronaire value (10^{-6} g/inch), bundle strength (g/tex) and uniformity ratio were recorded on plot basis and subjected to the statistical analysis. The results are presented and discussed here under the following headings.

- 4.1 Analysis of variance
- 4.2 Genetic variability, heritability and genetic advance as per cent of mean
- 4.3 Correlations
- 4.4 Path coefficient analysis
- 4.5 Combining ability
- 4.6 Heterosis

4.1 ANALYSIS OF VARIANCE

The data collected from the experimental material was subjected to the analysis of variance and was presented in the Table 4.1. The mean performances of the genotypes for different characters are presented in Appendix-I. It is perceptible from the the Table 4.1 that the treatment differences for all the characters were significant for all the genotypes indicating presence of sufficient amount of variability among the genotypes.

4.2 VARIABILITY, HERITABILITY ($h^2_{(b)}$) AND GENETIC ADVANCE AS PER CENT OF MEAN

The statistical analysis pertaining to variability, heritability ($h^2_{(b)}$) and genetic advance as per cent of mean (GAM) were worked out and presented in the Table 4.2. The results are discussed here under character-wise.

4.2.1 Days to 50% Flowering

Days to 50% flowering ranged from 53.67 (49 JRP $\times$ CNH 44) to 69.33 (NDLH 1938 $\times$ CNH 44) with an average of 61.03 days. Low estimates of PCV (6.97) and GCV (6.15) were recorded for this trait. These findings are in accordance with those of Kulkarni *et al.* (2011), Haritha *et al.* (2012), Vineela *et al.* (2013), Dhivya *et al.* (2014) and Rajamani *et al.* (2015).

High heritability (77.78) along with moderate genetic advance as per cent of mean (11.17) revealed the predominance of both additive and non-additive gene actions in the inheritance of this trait and offers the best possibility of improvement through progeny selection or any modified selection procedures aiming to exploit the additive gene effects. In contrary to this, high heritability and high genetic advance as per cent of mean was reported by Batool *et al.* (2010).

4.2.2 Plant Height (cm)

Plant height ranged from 99.20 cm (49 JRP $\times$ GISV 272) to 157.23 cm (NDLH 1938 $\times$ BS 49) with an average of 129.44 cm. The moderate PCV (11.31) and low GCV (9.86) indicated the availability of narrow variability for this trait. These findings are in agreement with the results of Rajanna (2010), Kulkarni *et al.* (2011), Haritha *et al.* (2012), Ahsan *et al.* (2015) and Rajamani *et al.* (2015).

High heritability (76.03) and moderate genetic advance as per cent of mean (17.71) were recorded for plant height indicating the role of both additive and non-additive gene actions. Further improvement of this character would be possible either through progeny selection or any modified selection procedures aiming to exploit the additive gene effects. In contrary to this high heritability and high genetic advance for this trait was reported by Kulkarni *et al.* (2011), Dhanalakshmi *et al.* (2012), Ranganatha *et al.* (2013), Dhivya *et al.* (2014), Erande *et al.* (2014) and Ahsan *et al.* (2015).

4.2.3 Number of Monopodia per Plant

The number of monopodia per plant ranged from 0.30 (GISV 272) to 2.66 (L 762 × CNH 50) with a mean value of 1.56. High PCV (40.73) and GCV (38.15) were recorded for this trait and the results are in agreement with the findings of Kishore *et al.* (2011), Dhanalakshmi *et al.* (2012), Venkatesh (2012), Vineela *et al.* (2013) and Rajamani *et al.* (2015).

High heritability (87.70) with high genetic advance as per cent of mean (73.59) indicating the role of additive gene action in the inheritance of this trait. Improvement of this trait can be aimed through direct selection. These research findings are in agreement with that of Haritha (2011), Vineela *et al.* (2013), Erande *et al.* (2014) and Vanaja (2014).

4.2.4 Number of Sympodia per Plant

The variation of number of sympodia per plant ranged from 14.63 (49 JRP × GISV 272) to 20.87 (NDLH 1938 × BS 47) with an average of 17.11. Moderate PCV (12.13) and low GCV (8.98) recorded for this trait. These findings are in agreement with those of Vijayalaxmi *et al.* (2008), Rajamani *et al.* (2009), Rao *et al.* (2009b), Bazi (2011) and Haritha *et al.* (2012).

High heritability (54.75) coupled with moderate genetic advance as per cent of mean (13.69) recorded for this trait, which indicates the involvement of both additive and non-additive gene actions in controlling this trait and further improvement of this character would be possible through progeny selection. These results are in contrary with the findings of Bazi (2011), Haritha *et al.* (2012), Vineela *et al.* (2013), Erande *et al.* (2014) and Rajamani *et al.* (2015).

4.2.5 Number of Bolls per Plant

The number of bolls per plant ranged from 37.67 (49 JRP × CNH 50) to 71.33 (L 762 × BS 49) with a mean value of 54.67. PCV (15.57) and GCV (11.07) were observed to be moderate. These results are in accordance with findings of Kishore *et al.* (2011), Venkatesh (2012), Dhivya *et al.* (2014) and Rajamani *et al.* (2015).

Moderate heritability (50.54) with moderate genetic advance as per cent of mean (16.21) indicated the role of non-additive gene action in the inheritance of this trait. Improvement of this trait can be aimed through cyclic hybridization, diallel selective mating and biparental mating. These results are in contrary with the findings of Haritha (2011), Vineela *et al.* (2013), Erande *et al.* (2014) and Rajamani *et al.* (2015).

4.2.6 Boll Weight (g)

The boll weight ranged from 3.60 (49 JRP) to 5.77 g (L 1057 × BS 49) with general mean of 4.77 g. Moderate estimates of PCV (11.04) and GCV (10.44) were recorded for this trait and the findings were in accordance with those of Rajanna (2010), Bazi (2011), Dhivya *et al.* (2014) and Ahsan *et al.* (2015).

High heritability (89.51) coupled with high genetic advance as per cent of mean (20.35) was observed indicating additive gene action for boll weight and offers the possibility of improvement through direct selection. In support to this, high heritability and high genetic advance for this trait was reported by Iqbal *et al.* (2011), Haritha *et al.* (2012), Ranganatha *et al.* (2013), Vineela *et al.* (2013), Erande *et al.* (2014), Rajamani *et al.* (2015) and Ahsan *et al.* (2015).

4.2.7 Seed index (g)

The variation for seed index ranged from 3.60 (49 JRP) to 12.00 g (49 JRP × CNH 44) with a general mean of 8.78 g. High estimates of PCV (33.26) and GCV (32.29) were recorded for seed index. These results are in agreement with Vineela (2011), Choudki *et al.* (2012), Anitha (2013) and Dhivya *et al.* (2014).

High heritability (94.24) coupled with high genetic advance as per cent of mean (64.57) was noticed for seed index revealed the preponderance of additive gene action which may be exploited through simple selection procedures. Similar results were reported by Naqib *et al.* (2010), Lu and Myers (2011), Vineela *et al.* (2013), Dhivya *et al.* (2014), Rajamani *et al.* (2015) and Ahsan *et al.* (2015).

4.2.8 Lint index (g)

The variation for lint index was ranged from 4.39 (L760 × BS 47) to 6.90 g (L 1057) with a general mean value of 5.55 g. The estimates of PCV (10.51) and GCV (8.50) were moderate. These results are in accordance with findings of Neelima *et al.* (2008) and Rao *et al.* (2009b).

High heritability (65.48) and moderate genetic advance as per cent of mean (14.17) indicating the role of both additive and non-additive gene actions and offers the possibility of improvement through mass, pureline selection, family selection or any other suitable modified selection procedures aiming to exploit the additive component. In contrary to this high heritability and moderate genetic advance in this trait was reported by Ravikesavan *et al.* (2008), Naqib *et al.* (2010), Haritha *et al.* (2012), Santoshkumar *et al.* (2012), Vineela *et al.* (2013) and Dhivya *et al.* (2014).

4.2.9 Ginning outturn (%)

The ginning outturn ranged from 30.57 (L 801 × BS 47) to 36.17% (L 804 × BS 49) with an average of 34.53%. PCV (4.20) and GCV (3.11) were recorded low for this trait. Similar results were earlier reported by Mahantesh (2009), Sarada *et al.* (2010), Haritha *et al.* (2012), Venkatesh (2012), Pujer *et al.* (2014) and Dhivya *et al.* (2014).

Moderate heritability (55.20) coupled with low genetic advance as per cent of mean (4.76) revealed the role of both additive and non-additive gene actions in the expression of this trait. Further improvement of this character would be possible either through heterosis breeding or population improvement through various forms of recurrent selection. In contrary to this high heritability and low genetic advance in this trait was reported by Rajanna (2010), Bazi (2011), Dhivya *et al.* (2014) and Rajamani *et al.* (2015).

4.2.10 2.5% span length (mm)

The range for 2.5% span length varied from 26.30 (CNH 50) to 33.43 mm (NDLH 1938 x GISV 272) with a general mean value of 30.64 mm. The estimates of PCV (5.50) and GCV (5.27) values were low and the findings are in agreement with Rajanna (2010), Kishore *et al.* (2011), Haritha *et al.* (2012), Natera *et al.* (2012), Dhivya *et al.* (2014) and Asha *et al.* (2015).

High heritability (91.87) coupled with moderate genetic advance as per cent of mean (10.40) indicating the role of additive and non-additive gene action in the inheritance of this trait. This can be improved through cyclic hybridization, diallel selective mating and biparental mating. In contrary to this, high heritability and high genetic advance for this trait was reported by Bazi (2011), Dhivya *et al.* (2014), Erande *et al.* (2014) and Rajamani *et al.* (2015).

4.2.11 Micronaire value (10^{-6} g/inch)

The micronaire value ranged from 3.40 (49 JRP $\times$ BS 47) to 4.63 10^{-6} g/inch (L 762 $\times$ BS 49) with a mean value of 4.06 10^{-6} g/inch. The PCV (8.30) and GCV (6.61) were low. The results are in broad agreement with Rajanna (2010), Kulkarni *et al.* (2010), Bazi (2011), Natera *et al.* (2012), Pujer *et al.* (2014) and Asha *et al.* (2015).

High heritability (63.42) combined with moderate genetic advance as per cent of mean (10.84) indicating the presence of both additive and non-additive gene actions in the inheritance of this trait and this can be improved through cyclic hybridization, diallel selective mating and biparental mating. In contrary to this high heritability and high genetic advance in this trait was reported by Haritha (2011), Rao and Gopinath (2013), Vineela *et al.* (2013) and Rajamani *et al.* (2015).

4.2.12 Bundle strength (g/tex)

The variation for bundle strength ranged from 20.47 (CNH 50) to 23.87 g/tex (BS 47) with a general mean value of 22.51 g/tex. The PCV (3.53) and GCV (3.00) were low and the results are in conformity with the research findings of Rajanna (2010), Vineela (2011), Haritha *et al.* (2012), Pujer *et al.* (2014) and Asha *et al.* (2015).

High heritability (72.11) and low genetic advance as per cent of mean (5.25) were recorded indicating the role of additive and non-additive gene actions in the inheritance of this trait. This can be improved through cyclic hybridization, diallel selective mating and biparental mating. These findings are in agreement with Haritha (2011), Kulkarni *et al.* (2011), Choudki *et al.* (2012), Vineela *et al.* (2013) and Vanaja (2014).

4.2.13 Uniformity ratio

The uniformity ratio ranged from 45.00 (49 JRP $\times$ GISV 272) to 49.00 (NDLH 1938 $\times$ BS 49) with an average value of 47.02. PCV (2.62) and GCV (1.62) were recorded low. These results are in accordance with the reports of Rajanna (2010), Vineela (2011), Haritha *et al.* (2012), Natera *et al.* (2012), Rao and Gopinath (2013), Pujer *et al.* (2014) and Asha *et al.* (2015).

Moderate heritability (38.11) and low genetic advance as per cent of mean (2.06) indicating the role of non-additive gene action in the inheritance of uniformity ratio and would give scope for improvement of this character either through heterosis

breeding or population improvement through various forms of recurrent selection. In contrary to this high heritability and low genetic advance in this trait was reported by Sakthi *et al.* (2007), Bazi (2011), Rao and Gopinath (2013), Vineela *et al.* (2013) and Rajamani *et al.* (2015).

4.2.14 Seed Cotton Yield per Plant (g)

The seed cotton yield per plant ranged from 154.67 (49 JRP × CNH 50) to 334.67 g (L 1057 × BS 49) with a general mean value of 231.35 g. PCV (18.47) and GCV (15.24) were moderate. These results are in agreement with that of Anitha (2013), Dhivya *et al.* (2014), Pujer *et al.* (2014) and Ahsan *et al.* (2015).

High heritability (68.03) and high genetic advance as per cent of mean (25.89) indicating the preponderance of additive gene action in the inheritance of seed cotton yield per plant and offers the scope for improvement through simple selection procedures. These research findings are parallel to the findings of Patnaik and Sial (2010), Iqbal *et al.* (2011), Choudki *et al.* (2012), Haritha *et al.* (2012), Ranganatha *et al.* (2013), Rao and Gopinath (2013), Vineela *et al.* (2013), Dhivya *et al.* (2014), Erande *et al.* (2014), Vanaja (2014) and Ahsan *et al.* (2015).

4.2.15 Lint Yield per Plant (g)

The lint yield per plant ranged from 48.74 (49 JRP × CNH 50) to 119.19 g (L 1057 × BS 49) with a general mean value of 80.48 g. PCV (19.55) and GCV (16.44) were moderate. These results are in agreement with that of Vineela (2011), Natera *et al.* (2012), Venkatesh (2012) and Rao and Gopinath (2013).

High heritability (70.78) along with high genetic advance as per cent of mean (28.50) indicating the preponderance of additive gene action in the inheritance of lint yield per plant and offers the scope for further improvement through simple selection procedures. Similar results were earlier reported by Rajanna (2010), Lu and Myers (2011), Iqbal *et al.* (2011), Venkatesh (2012) and Erande *et al.* (2014).

In the present study, wide genetic variability was observed for the characters viz., number of monopodia per plant, number of bolls per plant, boll weight, seed index, seed cotton yield per plant and lint yield per plant, where as it was narrow for the characters viz., days to 50% flowering, plant height, number of sympodia, lint index, ginning outturn, 2.5% span length, micronaire value, bundle strength and uniformity ratio.

High heritability in conjunction with high genetic advance as per cent of mean were recorded in case of number of monopodia per plant, boll weight, seed index, seed cotton yield per plant and lint yield per plant indicating the preponderance of additive gene action in the inheritance of these traits and offers the scope for further improvement through simple selection procedures.

High heritability coupled with moderate genetic advance as per cent of mean was observed for days to 50% flowering, plant height, number of sympodia per plant, lint index, micronaire value and 2.5% span length indicating the operation of both additive and non-additive gene actions in the inheritance of these traits.

High heritability coupled with low genetic advance as per cent of mean was observed for bundle strength indicating the role of non-additive gene action and further improvement of these trait would be possible through cyclic hybridization, diallel selective mating and biparental mating.

Moderate heritability and low to moderate genetic advance as percent of mean were recorded in case of number of bolls per plant, ginning-out turn and uniformity ratio the characters which are governed by additive gene action but influence of environment need to be exploited by heterosis breeding or population improvement through various forms of recurrent selection.

4.3 CORRELATIONS

Seed cotton yield is a polygenically controlled complex character resulting from multiplicative interaction of yield components. The cumulative effects of such characters determine the dependent variable yield. These characters play an important role in modifying the system of seed cotton yield as a whole in magnitude as well as in direction. Further, direct selection for seed cotton yield is not effective as it is a complex quantitative character and much influenced by environment. The change in one character brings about a series of changes in other characters, since they are interrelated. Therefore, the study of correlation between yield and yield components are of considerable importance in selection programmes. The phenotypic and genotypic correlation coefficients between seed cotton yield and other related component characters and among themselves were estimated for 13 parents and 40 crosses was presented in the Table 4.3. The results of correlation are discussed character wise here under.

4.3.1 Days to 50% Flowering

Days to 50% flowering had shown significant positive association with plant height (0.3208** and 0.4220**), boll weight (0.2028** and 0.2432**) and seed index (0.1733** and 0.2017**) and non-significant and positive association with seed cotton yield per plant (0.1015 and 0.1538) both at phenotypic and genotypic levels indicating the simultaneous improvement of these traits in the breeding programmes. This trait exhibited significant and negative association with lint index (-0.2257** and -0.2914**) at both phenotypic and genotypic levels.

It was evident that this trait had strong association with boll weight and seed index. This was in accordance with the research findings of An *et al.* (2008), Kumar *et al.* (2010), Bazi (2011) and Vineela (2011).

4.3.2 Plant Height (cm)

Plant height recorded significant positive association with number of monopodia per plant (0.3894** and 0.4517**), number of sympodia per plant (0.3132** and 0.4299**), boll weight (0.4610** and 0.5836**), seed index (0.4666** and 0.5771**), 2.5% span length (0.2130** and 0.2564**), micronaire value (0.2253** and 0.3263**) and lint yield per plant (0.3361** and 0.4701**) at both genotypic and phenotypic levels and with uniformity ratio (0.1775*) at genotypic level only. This trait showed significant and negative association with lint index (-0.2071** and -0.2739**) at both phenotypic and genotypic levels.

The results indicated that this trait had strong association with seed cotton yield per plant and selection for high seed cotton yield per plant based on plant height is beneficial. Similar results were reported earlier by Batool *et al.* (2010), Tulasi *et al.* (2012), Alkuddsi *et al.* (2013) and Asha *et al.* (2015) for monopodia, Alkuddsi *et al.* (2013), Rajamani *et al.* (2013) and Vanaja (2014) for sympodia.

4.3.3 Number of Monopodia per Plant

Number of monopodia per plant showed significant positive association with number of sympodia per plant (0.2707** and 0.4132**), seed index (0.2471** and 0.2671**), 2.5% span length (0.2758** and 0.3059**), micronaire value (0.2470** and 0.3144**), bundle strength (0.2244** and 0.2936**) and lint yield per plant (0.1890** and 0.2343**) at both phenotypic and genotypic levels. Number of bolls per plant (0.1571*) and seed cotton yield per plant (0.2008*) showed significant positive association at genotypic level only.

The results indicated that this trait had strong association with number of sympodia per plant, 2.5% span length, bundle strength, micronaire value and lint yield per plant. These results are in agreement with the findings of Rajanna *et al.* (2011), Venkatesh (2012) and Asha *et al.* (2015) for number of sympodia per plant, Mohan (2011), Pujera *et al.* (2014) and Reddy *et al.* (2015) for 2.5% span length, Rao and Rajamani (2009) for uniformity ratio and Mohan (2011) for bundle strength.

4.3.4 Number of Sympodia per Plant

The character, number of sympodia per plant exhibited significant positive correlation with number of bolls per plant (0.3263** and 0.4994*), ginning outturn (0.2265** and 0.4236**), micronaire value (0.3687** and 0.6160**), lint yield per plant (0.3155** and 0.4575**) and seed cotton yield per plant (0.2678** and 0.3855**) both at phenotypic and genotypic levels.

Similar trends were also evident from the studies of Rajanna *et al.* (2011), Wang *et al.* (2012), Asha *et al.* (2015) for number of bolls per plant, Tulasi *et al.* (2012), Venkatesh (2012) and Reddy *et al.* (2015) for seed index, Thiyagu *et al.* (2010) and Mohan (2011) for 2.5% span length, Haritha (2011) for bundle strength and Rahman *et al.* (2013), Rajamani *et al.* (2013) and Erande *et al.* (2014) for seed cotton yield per plant.

4.3.5 Number of Bolls per Plant

Phenotypic and genotypic correlation indicated that number of bolls per plant had shown significant positive correlation with ginning outturn (0.2107** and 0.4315**), micronaire value (0.4125** and 0.6290**), lint yield per plant (0.6213** and 0.9755*) and seed cotton yield per plant (0.6089** and 0.9570**) and significant negative association with 2.5% span length (-0.1553** and -0.1998**) at both at phenotypic and genotypic levels. For uniformity ratio (0.1586*) it showed significant positive association at genotypic level only.

These results indicated that number of bolls had significant positive association with seed cotton yield per plant at both the levels indicating that selection for high seed cotton yield per plant based on number of bolls per plant is beneficial. These results are in broad agreement with the findings of Pratap *et al.* (2007), Vineela (2011) and Venkatesh (2012) for ginning outturn, Thiyagu *et al.* (2010), Venkateswarlu *et al.* (2010b), Venkatesh (2012) and Asha *et al.* (2015) for micronaire value, Venkateswarlu *et al.* (2010b), Rajanna *et al.* (2011) and Reddy *et al.* (2015) for lint yield per plant, Venkatesh (2012), Vineela *et al.* (2012a), Wang *et al.* (2012) and Pujer *et al.* (2014) for seed cotton yield per plant.

4.3.6 Boll Weight (g)

At both phenotypic and genotypic level, boll weight had recorded significant positive association with seed index (0.6172** and 0.6651**), 2.5% span length (0.5133** and 0.5708**), lint yield per plant (0.3477** and 0.4171**) and seed cotton yield per plant (0.3936** and 0.4762**) indicating close association of these characters with boll weight and this meaningful association can be exploited in selection programme leading towards the improvement of cotton varieties. Boll weight also recorded significant and positive association with uniformity ratio (0.2557**) and with lint index showed significant negative association (-0.1729*) at genotypic level only. These results are in agreement with the reports of Wang *et al.* (2012) and Rajamani *et al.* (2013) for seed index, Asha *et al.* (2015) for 2.5% span length, Rao and Rajamani (2009), Kumar and Ravikesavan (2010) and Venkateswarulu *et al.* (2010b) for micronaire value, Rao (2008), Rajanna *et al.* (2011), Venkatesh (2012) and Asha *et al.* (2015) for lint yield per plant and Venkatesh (2012), Vineela *et al.* (2012a), Wang *et al.* (2012) and Reddy *et al.* (2015) for seed cotton yield per plant.

4.3.7 Seed index

Seed index had shown significant positive correlation with 2.5% span length (0.4415** and 0.4722**) and seed cotton yield per plant (0.2062** and 0.2188*) at both phenotypic and genotypic levels clearly indicates the dependent nature of these traits and selection for high seed cotton yield based on seed index is reliable. It showed significant negative correlation with ginning outturn (-0.2093** and -0.2684**) both at phenotypic and genotypic levels. It showed significant positive association with bundle strength (0.1667**) at genotypic level only. The significant positive correlation of seed index with 2.5% span length at both phenotypic and genotypic level are in conformity with the findings of Rajanna *et al.* (2011), Rajamani *et al.* (2013) and Pujer *et al.* (2014). For seed cotton yield per plant with Thiyagu *et al.* (2010), Rajamani *et al.* (2013) and Pujer *et al.* (2014).

4.3.8 Lint index

Both at phenotypic and genotypic level, lint index had shown significant positive correlation with ginning out turn (0.3239** and 0.2438**). It showed significant negative correlation with bundle strength (-0.1854**) and seed cotton yield per plant (-0.2137**) at genotypic level only this clearly indicates that selection for high seed cotton yield may not be reliable based on lint index.

Significant positive association of lint index with ginning outturn at phenotypic and genotypic the levels are in agreement with the reports of Haritha (2011), Mohan (2011), Rajanna *et al.* (2011), Venkatesh (2012) and Asha *et al.* (2015).

4.3.9 Ginning outturn

Ginning outturn had recorded significant positive correlation with micronaire value (0.2960** and 0.3986**), lint yield per plant (0.4449** and 0.5105**) and seed cotton yield per plant (0.2589** and 0.3612*) at both phenotypic and genotypic levels indicating the simultaneous selection for these traits would be beneficial and the results are in accordance with the reports of Rao (2008), Rajanna *et al.* (2011), Venkatesh (2012) and Reddy *et al.* (2015) for lint yield per plant and Haritha (2011), Tulasi *et al.* (2012), Venkatesh (2012) and Pujer *et al.* (2014) for seed cotton yield per plant.

4.3.10 2.5% span length

There was a strong association of 2.5% span length with bundle strength (0.3289** and 0.4129**) and non-significant and negative association with seed cotton yield per plant (-0.0168 and -0.0080) and lint yield per plant (-0.0207 and -0.0173) at both phenotypic and genotypic levels. The antagonistic and non significant association of seed cotton yield and 2.5% span length at genotypic and phenotypic levels respectively suggest that breeder should be very careful in selection programme based on association of 2.5% span length and seed cotton yield. Similar findings were observed by Kale *et al.* (2007), Rao (2008), Vijayalakshmi *et al.* (2008) and Rajamani *et al.* (2011).

4.3.11 Micronaire value

Micronaire recorded significant positive correlation with lint yield per plant (0.4067** and 0.5112**) and seed cotton yield per plant (0.3542** and 0.4441**) at both phenotypic and genotypic levels. Similar trends were also evident from the studies of Venkateswarulu *et al.* (2010b) and Rao and Gopinath (2013) for lint yield per plant and Venkateswarlu *et al.* (2010b), Vineela *et al.* (2012a) and Rao and Gopinath (2013) for seed cotton yield per plant.

4.3.12 Bundle strength

Bundle strength had exhibited significant positive correlation with lint yield per plant (0.3260**) and seed cotton yield per plant (0.3429*) at phenotypic level only and the results are similar to the previous findings of Venkatesh (2012) for lint yield per plant and Rao and Gopinath (2013) for seed cotton yield per plant.

4.3.13 Uniformity ratio

Uniformity ratio had exhibited significant positive correlation with lint yield per plant (0.3260**) and seed cotton yield per plant (0.3429*) at genotypic level only and the results are similar to previous findings of Venkatesh (2012) for lint yield per plant and Neelima *et al.* (2005), Rajamani *et al.* (2013) and Pujer *et al.* (2014) for seed cotton yield per plant.

4.3.14 Lint Yield per Plant

The character, lint yield per plant exhibited significant positive correlation with seed cotton yield per plant (0.9687** and 0.9742**) at both levels. This indicated that improvement in lint yield would have a positive effect on seed cotton yield. Pratap *et al.* (2007), Vijayalaxmi *et al.* (2008), Rajanna *et al.* (2011), Venkatesh (2012), and Reddy *et al.* (2015) recorded similar results for this trait.

The character association analysis revealed that plant height, number of sympodia per plant, number of bolls per plant, boll weight, seed index, ginning outturn, micronaire value and lint yield per plant were found to have significant positive association with seed cotton yield per plant at both phenotypic and genotypic levels. Hence, the above characters may be considered in selection programmes while improving seed cotton yield per plant.

4.4 PATH COEFFICIENT ANALYSIS

Yield being a complex character, is composed of several components some of which affect yield directly while others contribute towards it indirectly. Correlation studies provide an opportunity to study the magnitude and direction of association of yield with its components and also among various components. To accumulate optimum combination of yield contributing characters in a single genotype, it is essential to know the amplification of interrelationship of various characters with standard partial correlation or regression.

Through path analysis, the direct and indirect effects of different yield component traits on seed cotton yield were worked out at phenotypic and genotypic levels and presented in Tables 4.4 and 4.5 respectively. The phenotypic and genotypic path diagrams were given in Fig 1 and 2. The results are discussed character wise here under.

4.4.1 Days to 50% Flowering

At phenotypic level, the direct contribution of this character on seed cotton yield per plant was low and positive (0.0226). The indirect effect of this trait through plant height (0.0098) number of monopodia per plant (0.0056), number of bolls per plant (0.0005), boll weight (0.0028), seed index (0.0054), ginning outturn (0.0088), micronaire value (0.0001), 2.5% span length (0.0003) and lint yield per plant (0.0494) were positive. While, number of sympodia per plant (-0.0005), lint index (-0.0003), bundle strength (-0.0024) and uniformity ratio (-0.0005) showed negative indirect effects.

At genotypic level, the direct contribution of this character on seed cotton yield per plant was low and positive (0.0273). The indirect effect of this trait through plant height (0.0349), number of monopodia (0.0081), seed index (0.0068) ginning outturn (0.0142), 2.5% span length (0.0001), micronaire value (0.000) and lint yield per plant (0.0839) were positive. While, number of sympodia per plant (-0.0026), number of bolls per plant (-0.0030), boll weight (-0.0055), lint index (-0.0061), bundle strength (-0.0009) and uniformity ratio (-0.0036) showed negative indirect effects.

This trait had positive non significant correlation with seed cotton yield per plant (0.1015 and 0.1538) both at phenotypic and genotypic levels, respectively. The low direct effects indicate that days to 50% flowering had little effect on yield as its own but its effect on yield per plant may be through its component traits. Further non significant correlations indicate the independent association of this trait in improving yield per plant.

Rao *et al.* (2009a), Kumar *et al.* (2010), Venkateswarulu *et al.* (2010b), Rajanna *et al.* (2011), Vineela (2011), Rajamani *et al.* (2013) and Asha *et al.* (2015) also reported similar results.

4.4.2 Plant Height

At phenotypic level, the direct contribution of this character on seed cotton yield per plant was low and positive (0.0306). The indirect effect of this trait through days to 50% flowering (0.0072), number of bolls per plant (0.0016), boll weight (0.0063), seed index (0.0146), 2.5% span length (0.0010) and lint yield per plant (0.3510) were positive. While, number of monopodia per plant (-0.0175), number of sympodia per plant (-0.0048), lint index (-0.0003), ginning outturn (-0.0110), micronaire value (-0.0006), bundle strength (-0.0001) and uniformity ratio (-0.0007) were negative.

At genotypic level, the direct contribution of this character on seed cotton yield per plant was low and positive (0.0828). The indirect effect of this trait through days to 50% flowering (0.0115), seed index (0.0194), 2.5% span length (0.0006) and lint yield per plant (0.5239) were positive. While, number of monopodia per plant (-0.0327), number of sympodia per plant (-0.0177), number of bolls per plant (-0.0145), boll weight (-0.0132), ginning outturn (-0.0173), lint index (-0.0058), micronaire value (-0.0007) and uniformity ratio (-0.0038) were negative. This trait expressed significant positive correlation with seed cotton yield per plant (0.3775** and 0.5328**) at phenotypic and genotypic level respectively.

This trait possessed significant positive correlation with seed cotton yield per plant at both phenotypic and genotypic levels. The positive correlation of plant height with seed cotton yield might be attributed to its high positive indirect effect on seed cotton yield via lint yield per plant. Hence selection through this character may bring about improvement in seed cotton yield. These findings were in agreement with the results of Venkateswarulu *et al.* (2010b), Haritha (2011), Rajanna *et al.* (2011), Venkatesh (2012), Wang *et al.* (2012) and Erande *et al.* (2014).

4.4.3 Number of Monopodia per Plant

At phenotypic level, the direct contribution of this character on seed cotton yield per plant was low and negative (-0.0449). The indirect effect of this trait through plant height (0.0119), number of bolls per plant (0.0017), boll weight (0.0015), seed index (0.0077), lint index (0.0001), 2.5% span length (0.0013), uniformity ratio (0.0003) and lint yield per plant (0.1974) were positive. While days to 50% flowering (-0.0028), number of sympodia per plant (-0.0041), ginning outturn (-0.0039), micronaire value (-0.0006) and bundle strength (-0.0057) were negative.

The direct contribution of this character on seed cotton yield per plant was negative and low (-0.0724) at genotypic level. The indirect effect of this trait through plant height (0.0374), seed index (0.0090), lint index (0.0027), 2.5% span length (0.007), uniformity ratio (0.0020) and lint yield per plant (0.2611) were positive. While days to 50% flowering (-0.0030), number of sympodia per plant (-0.0170), number of bolls per plant (-0.0073), boll weight (-0.0033), ginning outturn (-0.0058), micronaire value (-0.0007) and bundle strength (-0.0025) were negative.

This trait expressed non-significant positive correlation with seed cotton yield per plant (0.1600) at phenotypic level and significant positive correlation (0.2008*) at genotypic levels and recorded low and negative direct effects at both the levels. This clearly indicates that direct selection for high seed cotton yield per plant based on number of monopodia per plant may not be reliable. It revealed that this trait should be improved through positive direct effect of lint yield per plant. These findings are in agreement with the results of Sarada *et al.* (2010), Tulasi *et al.* (2012), Vineela *et al.* (2012a), Rajamani *et al.* (2013) and Reddy *et al.* (2015).

4.4.4 Number of Sympodia per Plant

Direct effect of this trait on seed cotton yield per plant was negative and low (-0.0153) at phenotypic level and its indirect effect through days to 50% flowering (0.0007), plant height (0.0096), number of bolls per plant (0.0038), seed index (0.0001) and lint yield per plant (0.3295) were positive. Whereas, number of monopodia per plant (-0.0121), boll weight (-0.0004), ginning outturn (-0.0453), 2.5% span length (-0.0002), micronaire value (-0.0009), bundle strength (-0.0015) and uniformity ratio (-0.0001) were negative indirect effects.

This trait showed a negative (-0.0412) and low direct effect on seed cotton yield per plant at genotypic level. The indirect effects via days to 50% flowering (0.0017), plant height (0.0356), seed index (0.0012), lint index (0.0008), uniformity ratio (0.0032) and lint yield per plant (0.5099) were positive. While, the characters number of monopodia per plant (-0.0299), number of bolls per plant (-0.0231), boll weight (-0.0001), ginning outturn (-0.0700), 2.5% span length (-0.0002), micronaire value (-0.0013) and bundle strength (-0.0010) exhibited negative indirect effects through this character.

This trait expressed significant and positive correlation with seed cotton yield per plant (0.2678** and 0.3855**) and recorded low and negative direct effects at both phenotypic and genotypic levels, respectively. Positive and significant correlation between number of sympodia per plant and seed cotton yield per plant may be due to high and positive indirect effects *via* other characters. So restricted selection methods could be used for improving seed cotton yield. Similar trends were also evident from the studies of Rasheed *et al.* (2009), Rao *et al.* (2009a), Venkateswarlu *et al.* (2010b), Bazi (2011) and Reddy *et al.* (2015)

4.4.5 Number of Bolls per Plant

The direct effect of this trait was positive and low (0.116) at phenotypic level. The positive indirect effects were *via* days to 50% flowering (0.0009), plant height (0.0043), boll weight (0.0001), bundle strength (0.0016) and lint yield per plant (0.6490). While, the negative indirect effects of this trait were *via* number of monopodia per plant (-0.0064), number of sympodia per plant (-0.0050), seed index (-0.0026), ginning outturn (-0.0422), 2.5% span length (-0.0007), micronaire value (-0.0010) and uniformity ratio (-0.0006).

The direct effect of this trait was negative and low (-0.0462) at genotypic level. The positive indirect effects were *via* days to 50% flowering (0.0017), plant height (0.0254), boll weight (0.0002), lint index (0.0006), bundle strength (0.0005) and lint yield per plant (1.0871). While, the negative indirect effects of this trait were *via* number of monopodia per plant (-0.0114), number of sympodia per plant (-0.0206), seed index (-0.0041), ginning outturn (-0.0713), 2.5% span length (-0.0004), micronaire value (-0.0014) and uniformity ratio (-0.0034).

This trait had shown significant positive correlation (0.6089** and 0.9570**) and negative direct effects both at phenotypic and genotypic levels on seed cotton yield per plant. Therefore, the positive correlation may be due to high positive indirect effects *via* other characters. These results were in agreement with the findings of Alishah *et al.* (2008), Karademir *et al.* (2009), Vineela (2011) and Alkuddsi *et al.* (2013).

4.4.6 Boll Weight

At phenotypic level the direct effect was positive (0.0137) and low. The positive indirect effects contributed through days to 50% flowering (0.0046), plant height (0.0141), number of sympodia per plant (0.0005), number of bolls per plant (0.0000),

seed index (0.0193), 2.5% span length (0.0025), micronaire value (0.0001) and lint yield per plant (0.3632). The negative indirect effects produced through number of monopodia per plant (-0.0049), lint index (-0.0002), ginning outturn (-0.0168), bundle strength (-0.0017) and uniformity ratio (-0.0008).

At genotypic level the direct effect was negative and low (-0.0225). The indirect effect via number of monopodia per plant (-0.0106), number of sympodia per plant (-0.0001), lint index (-0.0036), ginning outturn (-0.0246), bundle strength (-0.0007) and uniformity ratio (-0.0054) were negative, and days to 50% flowering (0.0066), plant height (0.0483), number of bolls per plant (0.0004), seed index (0.0224), 2.5% span length (0.0012), micronaire value (0.0001) and lint yield per plant (0.4649) were positive.

It exhibited significant positive correlation with seed cotton yield per plant (0.3936** and 0.4762**) and low direct effects both at phenotypic and genotypic levels. Similar trends were also evident from the studies of Alishah *et al.* (2008), Rasheed *et al.* (2009), Patnaik and Sial (2010), Tulasi *et al.* (2012), Anitha (2013) and Vanaja (2014).

4.4.7 Seed index

Seed index exhibited significant positive correlation with seed cotton yield per plant (0.2062**) at phenotypic level. The direct effect was positive and low (0.0313). The indirect effects through days to 50% flowering (0.0039), plant height (0.0143), boll weight (0.0084), ginning outturn (0.0419), 2.5% span length (0.0021), micronaire value (0.0003) and lint yield per plant (0.1200) were positive. While, number of monopodia per plant (-0.0111), number of sympodia per plant (-0.0001), number of bolls per plant (-0.0010), lint index (-0.0001), bundle strength (-0.0036) and uniformity ratio (-0.0002) were negative in their indirect effects.

At genotypic level, this trait expressed significant positive correlation with seed cotton yield (0.2188**). The direct effect of seed index on seed cotton yield was positive and low (0.2188). The indirect effects through days to 50% flowering (0.0055), plant height (0.0478), number of bolls per plant (0.0056), ginning outturn (0.0443), 2.5% span length (0.0010), micronaire value (0.0003) and lint yield per plant (0.1215) were positive. While, number of monopodia per plant (-0.0194), number of sympodia per plant (-0.0014), boll weight (-0.0150), lint index (-0.0031), bundle strength (-0.0014) and uniformity ratio (-0.0005) were negative in their indirect effects.

The trait exhibited significant positive correlation of this trait on seed cotton yield and low direct effects at both phenotypic and genotypic levels. Though direct effect was low and positive, highly significant correlation with yield might have resulted due to outweighing indirect positive effects. These results are in agreement with the findings of Kaushik and Kapoor (2006), Rajanna *et al.* (2011), Tulasi *et al.* (2012), Rajamani *et al.* (2013), Erande *et al.* (2014) and Asha *et al.* (2015).

4.4.8 Lint index

The direct effect of lint index on seed cotton yield was positive and low (0.0015) at phenotypic level. The indirect effect through number of sympodia per plant (0.0005), number of bolls per plant (0.0001), micronaire value (0.0002), bundle strength (0.0039) and lint yield per plant (0.0028) were positive. While, via days to 50% flowering (-0.0051), plant height (-0.0063), number of monopodia per plant (-0.0044), boll weight (-0.0019), seed index (-0.0027), ginning outturn (-0.0648), 2.5% span length (-0.0003) and uniformity ratio (-0.0002) were negative.

The direct effect of lint index on seed cotton yield was positive and low (0.0210). The indirect effect through boll weight (0.0039), micronaire value (0.0004), bundle strength (0.0016) and uniformity ratio (0.0011) were positive. While, the indirect effects of this trait via days to 50% flowering (-0.0079), plant height (-0.0227), number of monopodia per plant (-0.0094), number of sympodia per plant (-0.0015), number of bolls per plant (-0.0014), seed index (-0.0050), ginning outturn (-0.0403), 2.5% span length (-0.0001) and lint yield per plant (-0.1534) were negative.

Lint index expressed non-significant negative correlation (-0.0769) at phenotypic level and significant negative correlation (-0.2137^{**}) at genotypic level. This trait showed positive direct effects both at phenotypic and genotypic levels. Similar trends were also evident from the studies of Sakthi *et al.* (2007), Vijayalaxmi *et al.* (2008), Kumar *et al.* (2010), Haritha (2011), Alkuddsi *et al.* (2013), Rajamani *et al.* (2013) and Erande *et al.* (2014).

4.4.9 Ginning outturn

Ginning outturn showed moderate and negative direct effect (-0.2001) at phenotypic level. At phenotypic level, this trait had significant positive correlation (0.2589*) with seed cotton yield per plant. However, the indirect effect of this trait

viaplant height (0.0017), number of bolls per plant (0.0024), boll weight (0.0011), lint index (0.0005), 2.5% span length (0.0002), bundle strength (0.0016) and lint yield per plant (0.4647) were positive. While, indirect effect of this trait through days to 50% flowering (-0.0010), number of monopodia per plant (-0.0009), number of sympodia per plant (-0.0035), seed index (-0.0065), micronaire value (-0.0007) and uniformity ratio (-0.0005) were negative and low.

At genotypic level it showed negative and moderate direct effect (-0.1652) on seed cotton yield per plant. At genotypic level, this trait exhibited significant positive correlation with seed cotton yield per plant (0.3612**). The indirect effects viaplant height (0.0087), lint index (0.0051), bundle strength (0.0013) and lint yield per plant (0.5689) were positive. While, the characters viz., days to 50% flowering (-0.0023), number of monopodia per plant (-0.0025), number of sympodia per plant (-0.0174), number of bolls per plant (-0.0199), boll weight (-0.0034), seed index (-0.0090), micronaire value (-0.0009) and uniformity ratio (-0.0022) showed negative indirect effects.

This trait showed significant and positive correlation with seed cotton yield per plant and negative direct effects at both phenotypic and genotypic levels. High and positive correlation between ginning outturn and seed cotton yield per plant may be due to high indirect effects through plant height, lint index, bundle strength and lint yield per plant. So that greater emphasis should be given to these traits in cotton yield improvement programmes. These results are in agreement with the findings of Shazia *et al.* (2010), Venkateswarlu *et al.* (2010b), Vineela (2011), Venkatesh (2012), Alkuddsi *et al.* (2013), Rajamani *et al.* (2013) and Asha *et al.* (2015).

4.4.10 2.5% span length

At phenotypic level, the direct contribution of this character on seed cotton yield per plant was positive and low (0.0048). The indirect effects through days to 50% flowering (0.0013), plant height (0.0065), number of sympodia per plant (0.0007), boll weight (0.0070) and seed index (0.0138) were positive. Whereas, the characters viz., number of monopodia per plant (-0.0124), number of bolls per plant (-0.0018), lint index (-0.0001), ginning outturn (-0.0063), bundle strength (-0.0083) and lint yield per plant (-0.0216) exhibited negative indirect effects.

This trait expressed positive and low (0.0022) direct effect on seed cotton yield per plant at genotypic level. The indirect effect through days to 50% flowering (0.0016), plant height (0.0212), number of sympodia per plant (0.0034), number of bolls per plant (0.0092), seed index (0.0159), micronaire value (0.0001), uniformity ratio (0.0007) were positive. While, the characters number of monopodia per plant (-0.0222), boll weight (-0.0129), lint index (-0.0014), ginning outturn (-0.0029), bundle strength (-0.0035) and lint yield per plant (-0.0193) have shown negative indirect effects.

This trait had non-significant negative correlation (-0.0165 and -0.0080) with seed cotton yield per plant both at phenotypic and genotypic levels. 2.5% span length exhibited positive direct effects both at phenotypic and genotypic levels. Similar trends were also evident from the studies of Sarada *et al.* (2010), Rajanna *et al.* (2011), Rao and Gopinath (2013), Erande *et al.* (2014) and Asha *et al.* (2015).

4.4.11 Micronaire value

At phenotypic level, the direct contribution of this character on seed cotton yield per plant was negative and low (-0.0025). The indirect effects of this trait through plant height (0.0069), number of bolls per plant (0.0048), bundle strength (0.0012), uniformity ratio (0.0001) and lint yield per plant (0.4248) were positive whereas, days to 50% flowering (-0.0011), number of monopodia per plant (-0.0111), number of sympodia per plant (-0.0057), boll weight (-0.0004), seed index (-0.0035), lint index (-0.0001), ginning outturn (-0.0592) and 2.5% span length (-0.0001) exhibited negative indirect effects.

Direct effect of micronaire was negative and low (-0.0022) at genotypic level. The indirect effects of this trait through plant height (0.0270), boll weight (0.0008), uniformity ratio (0.0008) and lint yield per plant (0.5697) were positive whereas, days to 50% flowering (-0.0002), number of monopodia per plant (-0.0228), number of sympodia per plant (-0.0254), number of bolls per plant (-0.0291), seed index (-0.0047), lint index (-0.0040), ginning outturn (-0.0658), 2.5% span length (-0.0001), and bundle strength (-0.0001) exhibited negative and indirect effects.

This trait exhibited positive and significant correlation (0.3542** and 0.4441**) and low and negative direct effects both at phenotypic and genotypic levels. High and positive association between seed cotton yield per plant and micronaire value

may be due to out-weighed indirect effects through other characters. These results are in agreement with the findings of Anandan (2009), Venkateswarlu *et al.* (2010b), Bazi (2011), Haritha (2011), Venkatesh (2012) and Vanaja (2014).

4.4.12 Bundle strength

This trait showed low and negative direct effect (-0.0253) on seed cotton yield per plant at phenotypic level. The indirect effects via days to 50% flowering (0.0021), plant height (0.0001), boll weight (0.0009), seed index (0.0044), ginning outturn (0.0123), 2.5% span length (0.0016) and micronaire value (0.0001) were positive in their indirect effects. While, the characters number of monopodia per plant (-0.0101), number of sympodia per plant (-0.0009), number of bolls per plant (-0.0008), lint index (-0.0002), uniformity ratio (-0.0001) and lint yield per plant (-0.0548) expressed negative and indirect effects.

At genotypic level, the direct contribution of this character on seed cotton yield per plant was negative and low (-0.0086). The indirect influence of this character through days to 50% flowering (0.0028), plant height (0.0002), number of bolls per plant (0.0029), seed index (0.0056), ginning outturn (0.0243) and 2.5% span length (0.0009) were positive. While, the characters number of monopodia per plant (-0.0213), number of sympodia per plant (-0.0050), boll weight (-0.0018), lint index (-0.0039), uniformity ratio (-0.0028) and lint yield per plant (-0.0985) were negative in their indirect effects.

This trait showed non-significant negative (-0.0706 and -0.1051) association with seed cotton yield per plant both at phenotypic and genotypic levels respectively. Low direct effect indicated that selection for this trait would not be realized in increased seed cotton yield per plant. Thus, indirect positive effects are to be considered. Similar trends were also evident from the studies of Murthy *et al.* (2006), Sakthi *et al.* (2007), Padmavathi (2008), Sarada (2010), Rajanna *et al.* (2011) and Anitha (2013).

4.4.13 Uniformity ratio

At phenotypic level, the direct effect of this character on seed cotton yield per plant was negative and low (-0.0054). The indirect effects via days to 50% flowering (0.0019), plant height (0.0042), number of monopodia per plant (0.0023), number of bolls per plant (0.0013), boll weight (0.0020), seed index (0.0010), lint index (0.0001) and lint yield per plant (0.1239) were positive. While, the characters, number of sympodia per plant (-0.0002), ginning outturn (-0.0191) and bundle strength (-0.0007) showed negative indirect effects.

Direct effect of uniformity ratio on seed cotton yield was negative and low (-0.0213) at genotypic level. The indirect effects via days to 50% flowering (0.0046), plant height (0.0147), number of monopodia per plant (0.0068), number of sympodia per plant (0.0061), seed index (0.0009), micronaire value (0.0001) and lint yield per plant (0.3632) were positive. While, the characters, viz., number of bolls per plant (-0.0073), boll weight (-0.0058), lint index (-0.0011), ginning outturn (-0.0169), 2.5% span length (-0.0001) and bundle strength (-0.0011) had shown negative indirect effects.

Uniformity ratio had positive and non-significant correlation (0.1114) at phenotypic level and positive and significant correlation (0.3429^{**}) at genotypic level. This trait also recorded low and negative direct effects at both the levels. Direct selection for improving seed cotton yield based on this character may not be gainful. These results are in agreement with the findings of Sakthi *et al.* (2007), Anandan (2009), Sarada *et al.* (2010), Haritha (2011), Venkatesh (2012) and Reddy *et al.* (2015).

4.4.14 Lint Yield per Plant

This trait recorded significant positive (0.9687^{**}) correlation with seed cotton yield per plant at phenotypic level. The direct influence of this character was positive and high (1.0445). The indirect contribution of this character via., days to 50% flowering (0.0011), plant height (0.0103), number of bolls per plant (0.0072), boll weight (0.0048), seed index (0.0036) and bundle strength (0.0013) were positive. Negative indirect effects produced through number of monopodia per plant (-0.0085), number of sympodia per plant (-0.0048), ginning outturn (-0.0890), 2.5% span length (-0.0001), micronaire value (-0.0010) and uniformity ratio (-0.0006).

A critical view revealed that the correlation of lint yield per plant with seed cotton yield per plant was positive and significant (0.9742^{**}) at genotypic level. The direct effect of lint yield per plant on seed cotton yield per plant was positive and high (1.1144). The indirect effects via., days to 50% flowering (0.0021), plant height (0.0389), seed index (0.0037) and bundle strength (0.0008) were positive. The negative indirect effects were contributed through number of monopodia per plant (-0.0170), number of sympodia per plant (-0.0188), number of bolls per plant (-0.0451), boll weight (-0.0094), lint index (-0.0029), ginning outturn (-0.0843), micronaire value (-0.0011) and uniformity ratio (-0.0069).

This trait expressed significant positive (0.9687** and 0.9742**) correlation with seed cotton yield per plant at both phenotypic and genotypic levels. High positive direct effects (0.9687 and 0.9742) and positive correlations with seed cotton yield suggests selection through this trait will be effective on the seed cotton yield positively. These results were in conformity with the findings of Pratap *et al.* (2007), Vijayalaxmi *et al.* (2008), Rajanna *et al.* (2011), Venkatesh (2012), Vineela *et al.* (2012a), Anitha (2013), Erande *et al.* (2014) and Reddy *et al.* (2015).

In plant breeding, it is very difficult to have complete knowledge of all component traits of yield. The residual effect permits precise explanation about the pattern of interaction of other possible components of yield. In other words, residual effect measures the role of the possible independent variables which were not included in the study on the dependent variable. In the present study, the residual effect observed at phenotypic (0.1357) and genotypic (0.1245) explains that the characters chosen for path analysis were adequate and appropriate.

The path analysis indicated that plant height, seed index, lint index and lint yield per plant showed direct positive effects and significant correlation with seed cotton yield per plant. The present study revealed that major emphasis should be laid on selection process with lint yield per plant without sacrificing desirable fibre quality by adopting restricted selection model.

4.5 Combining Ability and Gene Action

The knowledge of genetic structure and mode of inheritance of quantitative and qualitative traits help the breeders to employ suitable breeding method for improvement of these traits. Combining ability analysis is an important tool for selection of the desirable parents together with the information regarding nature and magnitude of gene controlling quantitative and qualitative traits. The information on gene action and combining ability helps in identifying the best combiners which may be hybridized either to exploit heterosis or to produce the transgressive or recombinant segregants in F₂ and subsequent generations. Exploitation of heterosis is primarily dependant on the screening and selection of the lines in the available germplasm that could produce better combinations of important characters.

The entire genetic variability observed in the analysis for each trait was partitioned into its components *i.e.* general and specific combining ability (Sprague and Tatum, 1942). General combining ability (*gca*) is used to designate the average

performance of a line in hybrid combinations while specific combining ability (*sca*) define those cases in which certain combinations do relatively better or worse than expected on the basis of the average performance of the lines involved. The general combining ability (*gca*) effects were due to the additive type of gene action whereas, specific combining ability (*sca*) effects are due to the genes which are non-additive *i.e.* either dominant or epistatic in nature (Sprague and Tatum, 1942).

The relative importance of general and specific combining ability can be assessed by estimating the components of variance and expressed in the ratio $\sigma^2_{gca}/\sigma^2_{sca}$ (Singh and Chaudhary, 1977). The closer the ratio to unity, greater is the magnitude of additive gene action and *vice versa*. Further the gene action can be confirmed by the estimates of narrow sense heritability. Higher values of narrow sense heritability indicate the presence of additive gene action.

The purpose of this study was to determine the *gca* and *sca* effects for seed cotton yield, yield contributing characters and fibre quality parameters so as to choose appropriate parents and hybrids for the genetic enhancement.

In present field experiment, forty intra-specific cross combinations were made in a line x tester design utilizing 8 lines (*G. hirsutum* L.) and 5 testers (*G. hirsutum* L.) during *kharif*, 2012-13. The forty F_1 's along with 13 parents were evaluated during *kharif*, 2013-14 to study the combining ability and gene action governing 15 traits *viz.*, days to 50% flowering, plant height (cm), number of monopodia per plant, number of sympodia per plant, number of bolls per plant, boll weight (g), seed index (g), lint index (g), ginning outturn (%), 2.5% span length (mm), micronaire value (10^{-6} g/inch), bundle strength (g/tex), uniformity ratio, lint yield per plant (g) and seed cotton yield per plant (g).

The analysis of variance for combining ability revealed significant differences among crosses for all the traits and line x tester effects for all the characters except for micronaire value (Table 4.6). The analysis of variance also revealed significant differences among the lines for plant height, number of monopodia per plant, number of sympodia per plant, boll weight, seed index, micronaire value and bundle strength and in testers for days to 50% flowering, plant height, number of monopodia per plant and uniformity ratio.

The character-wise estimates of *gca* effects of parents and *sca* effects of crosses are presented in Tables 4.7 to 4.11 and the estimates of genetic components of variance and proportional contribution of lines, testers and line x tester interaction to the total variance are presented in the Table 4.12. The ratio of $\sigma^2_{gca}/\sigma^2_{sca}$ gene action studies of seed cotton yield and its component characters are presented in the Table 4.13. Good general combiners in lines and testers for seed cotton yield and its component traits are presented in the Table 4.14. Individual character-wise results are discussed here under.

4.5.1 Days to 50% Flowering

The line, 49 JRP (-1.55**) and the tester, GISV 272 (-3.28**) exhibited significant negative *gca* effects suggesting that they were good general combiners with favourable genes for earliness. These parents may be involved in basic breeding programmes for improvement of this trait.

The proportional contribution of lines, testers and line $\times$ tester were 9.16%, 44.65% and 46.18 %, respectively, reveal that the line $\times$ tester component had contributed more towards genetic variance. The lines contributed less when compared to the testers. The *sca* component of variance (9.72) was significantly greater than the *gca* component (4.74). The ratio of *gca* component of variance to *sca* variance was 0.49 which revealed the operation of non-additive gene action. Thus this character can be improved by selecting breeding methods involving selection, inter mating the selected parents in subsequent generations followed by reselection. Heterosis breeding may also be tried to exploit non-additive component. These are in agreement with the reports of Deosarkar *et al.* (2009b), Patil *et al.* (2011b), Haritha *et al.* (20012) and Simon *et al.* (2013).

Among 40 crosses evaluated, seven crosses viz., L 762 $\times$ BS 49 (-4.12**), L 804 $\times$ CNH 50 (-3.82**), NDLH 1938 $\times$ GISV 272 (-2.65**), NDLH 1938 $\times$ BS 47 (-2.65**), L 1060 $\times$ BS 49 (-6.78**), 49 JRP $\times$ CNH 44 (-5.70**) and L 788 $\times$ CNH 44 (-5.50**) possessed negative and significant *sca* effects in desirable direction. Based on *sca* effects and *per se* performance the crosses, 49 JRP $\times$ CNH 44 (high $\times$ low) and L 804 $\times$ CNH 50 (low $\times$ low) were adjudged as the best specific cross combinations. High $\times$ low *gca* effects resulted in superior cross combinations which may be due to complementary gene action and also revealed the importance of both additive and non-additive gene actions. The cross between two low combiners revealed the presence of non-additive interallelic interaction.

4.5.2 Plant Height (cm)

Among the lines NDLH 1938 (9.25*) and L 1057 (6.90**) and the testers, CNH 50 (4.33**) and BS 49 (8.60**) exhibited significant and positive *gca* effects and were found to be good general combiners in hybridization programme for improving plant height.

The tester (43.81%) proportional contribution to the genetic variance was more as compared to the lines (39.52%) and line x tester (16.67%). The estimated component of variance due to *gca* (61.22**) was greater in magnitude than *sca* (13.61*). The ratio of general combining ability component of variance to specific combining ability of variance was 4.49, which revealed the operation of additive gene action and the possibility of improvement of this trait through simple selection procedures in recombinant breeding. These results are in agreement with the findings of Bhaskaran and Ravikesavan (2008), Soomro *et al.* (2010), Haritha *et al.* (2012) and Natera *et al.* (2012).

Out of 40 crosses evaluated, two crosses, L 762 x CNH 50 (10.12**) and 49 JRP x BS 47 (9.92*) showed significant positive *sca* effects. Based on *per se* and *sca* performance the cross, L 762 x CNH 50 (10.12**) (high x high) was found to be superior and indicated the predominance of additive genetic component of variance which can be exploited through simple selection procedures.

4.5.3 Number of Monopodia per Plant

The line, L 762 (0.57**) and the tester, NDLH 1938 (0.56**) exhibited significant positive *gca* effects suggesting that they were good general combiners for improving this character.

The tester (47.36%) proportional contribution to the genetic variance was more as compared to the lines (34.82%) and line x tester (17.82%). The estimated components of variance due to *gca* (0.16**) was greater in magnitude than *sca* (0.07**). The ratio of general combining ability component of variance to specific combining ability of variance was 2.296, which revealed the operation of additive gene action and the possibility of improvement of this trait through simple selection procedures in recombinant breeding. These results are in agreement with the findings of Raju (2005), Kiani *et al.* (2007), Mohammad *et al.* (2010) and Mohan (2011).

Six crosses L 762 x CNH 50 (0.48**), L 804 x CNH 44 (0.26**), L 1057 x CNH 44 (0.31**), L 1060 x CNH 50 (0.29**), 49 JRP x BS 47 (0.29**), 49 JRP x BS 49 (0.30**) and L 788 x BS 47 (0.29**) showed significant positive *sca* effects. Based on *per se* performance and *sca* effects the cross, L 762 × CNH 50 (high x low) was found to be superior. The cross between high × low general combiners resulted in superior cross combination due to better nicking ability.

4.5.4 Number of Sympodia per Plant

The lines L 804 (1.77**) and L 762 (1.33**) and CNH 50 (0.76**) in testers exhibited significant positive *gca* effects suggesting that they were good general combiners for improving this character.

Lines (44.53%) component had major proportional contribution to the genetic variance as compared to testers (11.42%) and line x tester (44.04%). The estimated components of variance due to *gca* (0.62**) was lower than *sca* (1.42**). The ratio of general combining ability component of variance to specific combining ability of variance was 0.433, which revealed the operation of non-additive gene action. This showed the possibility of improvement of this trait through selection, inter-mating among selected ones reselection besides heterosis breeding. Similar results were earlier reported by Wankhade *et al.* (2008), Deosarkar *et al.* (2009b), Mahantesh *et al.* (2010), Vineela *et al.* (2012b), Alkuddsi *et al.* (2013) and Vanaja (2014).

Out of 40 cross combinations evaluated, five crosses L 762 x GISV 272 (1.78**), NDLH 1938 x CNH 50 (1.74**), NDLH 1938 x BS 47 (2.27**), L 1057 x CNH 44 (2.22**) and L 1057 x BS 49 (1.66**) showed significant positive *sca* effects. The cross combination, NDLH 1938 × BS 47 (high x high) found to be superior as it recorded high *per se* performance and *sca* effects. The high x high general combiners indicated the predominance of additive genetic component of variance which can be exploited through simple selection procedures.

4.5.5 Number of Bolls per Plant

The lines, L 762 (04.70**) and NDLH 1938 (5.43**) exhibited significant positive *gca* effects and identified as good general combiners for improving boll weight. None of the tester exhibited significant *gca* effects.

Lines (34.96%) component had major proportional contribution to the genetic variance as compared to testers (3.28%) and line x tester (61.76%). The estimated components of variance due to *gca* (2.45*) was lower than *sca* (38.21**). The ratio of

general combining ability component of variance to specific combining ability of variance was 0.064, which revealed the operation of non-additive gene action. Breeding methods involving selection, intermating among selected ones and reselection may help to improve this trait besides exploiting the methods of heterosis breeding. Similar results were earlier reported by Patil *et al.* (2011b), Haritha *et al.* (2012), Shinde *et al.* (2012), Vineela *et al.* (2012b), Alkuddsi *et al.* (2013) and Simon *et al.* (2013).

Among all the cross combinations only six crosses L 762 x GISV 272 (7.68**), L 762 x BS 49 (10.97**), L 804 x CNH 44 (9.66**), NDLH 1938 x GISV 272 (10.27**), L 1057 x BS 49 (12.83**) and 49 JRP x CNH 44 (9.39**) showed significant positive *sca* effects. Based on *per se* performance and *sca* effects L 762 x BS 49 (high x high) and NDLH 1938 x GISV 272 (high x low) were found to be superior. The high x high general combiners indicated the predominance of additive genetic component of variance which can be exploited through simple selection procedures. The high x low general combiners indicated the role of additive x non-additive genetic component of variance and superiority resulted may be due to better nicking ability.

4.5.6 Boll Weight (g)

The lines, NDLH 1938 (0.09*), L 1057 (0.35**) and L 788 (0.27**) exhibited significant positive *gca* effects and identified as good general combiners for improving boll weight. Among the testers BS 49 (0.19*) exhibited significant positive *gca* effects.

The proportion of lines (41.70%) had contributed more to the genetic variance as compared to the testers (15.26%) and line x tester (43.04%). The estimated components of variance due to *gca* (0.022**) was lower than *sca* (0.055*). The ratio of general combining ability component of variance to specific combining ability of variance was 0.400, which revealed the operation of non-additive gene action. Breeding methods involving selection, intermating among selected ones and reselection may help to improve this trait besides exploiting the methods of heterosis breeding. Similar results were earlier reported by Deosarkar *et al.* (2009b), Senthilkumar *et al.* (2010), Mohan (2011), Vineela *et al.* (2012b), Alkuddsi *et al.* (2013) and Vanaja (2014).

Seven crosses viz., L 1057 x BS 49 (0.25**), L 1060 x CNH 50 (0.44**), L 1060 x BS 49 (0.20*), 49 JRP x CNH 44 (0.26*), L 788 x CNH 50 (0.24*), L 801 x GISV 272 (0.38**) and L 801 x CNH 44 (0.34**) showed significant positive *sca* effects. Based on *per se* and *sca* performance the hybrid, L 1057 x BS 49 (high x high) was found to be superior indicated the predominance of additive genetic component of variance which can be exploited through simple selection procedures.

4.5.7 Seed index (g)

L 1060 (0.41*), 49 JRP (1.18**) and L 801 (0.49**) in lines and CNH 44 (0.42**) in testers exhibited significant positive *gca* effects implying that they are good general combiners and can be used in hybridization programme for improving seed index in cotton.

Lines (45.53%) component had major proportional contribution to the genetic variance as compared to testers (12.41%) and Line x tester (42.06%). The estimated components of variance due to *gca* (0.171**) was lower than *sca* (0.345**). The ratio of general combining ability component of variance to specific combining ability of variance was 0.496, which revealed the operation of non-additive gene action. Breeding methods involving selection, intermating among selected ones and reselection may help to improve this trait besides exploiting the methods of heterosis breeding. Similar results were earlier reported by Soomro *et al.* (2010), Mohan (2011), Patil *et al.* (2011b), Venkatesh (2012), Vineela *et al.* (2012b) and Anitha (2013).

The cross combinations, L 762 x GISV 272 (0.99**), NDLH 1938 x CNH 50 (1.52**), L 1057 x BS 49 (0.99**), L 1060 x CNH 50 (0.82**) and L 788 x BS 47 (0.85*) showed significant positive *sca* effects. The hybrids, NDLH 1938 x CNH 50 (low x high) and L 1060 x CNH 50 (high x high) were recorded high *per se* performance and *sca* effects and considered to be superior. Low x high general combiners involved crosses resulted into superior cross combinations may be due to better nicking ability. Whereas, the superior cross with high x high general combiners indicated the predominance of additive genetic component of variance which can be exploited through simple selection procedures.

4.5.8 Lint index (g)

The estimates of *gca* effects were significant and positive for the lines, L 804 (0.20**), L 1060 (0.26*) and 49 JRP (0.26*) and for the tester CNH 44 (0.20**) found to be good general combiners and may be used in hybridization programme for improving this character.

The proportional contribution of line x tester (62.78%) to the genetic variance was more as compared to lines (22.72%) and testers (14.50%). The estimated components of variance due to *gca* (0.015**) was lower than *sca* (0.143**). The ratio of general combining ability component of variance to the specific combining ability of

variance was 0.105, which revealed the operation of dominant gene action. As dominant gene action was predominant, breeding methods involving selection, intermating among selected ones and reselection may help to improve this trait besides exploiting different methods of heterosis breeding. Similar results are earlier reported by Patil *et al.* (2011b), Haritha *et al.* (2012), Venkatesh (2012), Vineela *et al.* (2012b), Alkuddsi *et al.* (2013) and Vanaja (2014).

Out of 40 cross combinations evaluated, five crosses showed significant positive *sca* effects viz., L 762 x GISV 272 (0.63**), NDLH 1938 x CNH 50 (0.72**), L 1057 x BS 49 (0.52**), L 788 x BS 47 (0.73**) and L 801 x CNH 50 (0.34*). Based on *per se* and *sca* performance the cross, NDLH 1938 × CNH 50 (low x high) identified as promising which indicated the role of additive and non-additive gene action. The superiority of the cross combinations may be due to complementary gene action.

4.5.9 Ginning outturn (%)

The estimates of *gca* effects were significant and positive for the lines L 804 (0.80**) and L 1057 (1.00**) which were found to be good general combiners. None of the tester exhibited significant and positive *gca* effects.

The proportional contribution of line x tester (67.22%) to the genetic variance was more as compared to lines (30.03%) and testers (2.75%). The estimated components of variance due to *gca* (0.01) was lower than *sca* (1.39). The ratio of general combining ability component of variance to specific combining ability of variance was 0.007, which revealed the operation of non-additive gene action and breeding methods involving selection, intermating among the selected ones, reselection and heterosis breeding may help to improve this trait. Similar results were earlier reported by Patel *et al.* (2012), Vineela *et al.* (2012b), Alkuddsi *et al.* (2013) and Vanaja (2014).

Among the 40 hybrids only five crosses showed significant positive *sca* effects viz., L 1060 x BS 47 (1.58**), L 788 x CNH 50 (1.59**), L 788x BS 47 (1.18*), L 801 x CNH 50 (1.77**) and L 801 x GISV 272 (1.93**). Based on *per se* performance and *sca* effects the cross L 1060 × BS 47 (high x low) was found to be superior. The superiority of high x low general combiners involving crosses may be due to the better nicking ability.

4.5.10 2.5% span length (mm)

The lines, L 804 (0.49**), NDLH 1938 (0.28**), L 788 (0.83**) and L 801 (0.85**) and the testers CNH 44 (0.55**) and BS 47 (0.32**) exhibited positive significant *gca* effects and were found to be good general combiners in hybridization programme for improving 2.5% span length of the fibre.

The proportional contribution of line x tester (62.35%) to the genetic variance was more as compared to lines (29.07%) and testers (8.57%). The estimated components of variance due to *gca* (0.094*) was lower than *sca* (1.392*). The ratio of general combining ability component of variance to specific combining ability of variance was 0.068, which revealed the operation of non-additive gene action and breeding methods involving selection, intermating among the selected ones, reselection and heterosis breeding may help to improve this trait. Similar results were earlier reported by Mahantesh *et al.* (2010), Singh *et al.* (2010), Haritha *et al.* (2012), Vineela *et al.* (2012b) and Vanaja (2014).

The cross combinations, L 762 x CNH 44 (0.71**), L 804 x BS 49 (0.91**), NDLH 1938 x GISV 272 (1.52**), NDLH 1938 x BS 49 (0.75**), L 1057 x CNH 50 (1.00**), L 1057 x BS 47 (1.24**), L 1060 x CNH 44 (0.96**), 49 JRP x GISV 272 (0.70*), 49 JRP x BS 49 (2.43**), L 788 x BS 47 (1.51**) and L 801 x BS 47 (0.59**) registered significant positive *sca* effects. The hybrids, NDLH 1938 × GISV 272 (high × high), L 788 × BS 47 (high × high) and 49 JRP × BS 49 (low x low) were found to be superior as they recorded high *per se* performance and *sca* effects. The crosses between two low combiners producing significant *sca* effects revealed the presence of non-additive gene action. The cross with high × high *gca* combiners revealed additive and additive × additive gene action which can be exploited through simple selection procedures.

4.5.11 Micronaire value (10^{-6} g/inch)

The estimates of *gca* effects were significant and positive for the lines, L 762 (0.43**), L 804 (0.13*) and L 788 (0.16**) were found to be good general combiners and may be involved in basic breeding programmes for improvement of micronaire value of the fibre. None of the tester exhibited significant and positive *gca* effects.

The proportion of lines (87.70%) had contributed more to the genetic variance as compared to the testers (0.32%) and line x tester (11.98%). The estimated components of variance due to *gca* (0.032**) was higher than *sca* (0.001). The ratio of general combining ability component of variance to specific combining ability of

variance was 32.00, which revealed the operation of additive gene action. This trait can be improved by hybridization followed by simple selection through pedigree method of breeding. Similar results were earlier reported by Kalpande *et al.* (2008), Kamboh *et al.* (2008), Wandhare *et al.* (2010b) and Anitha (2013).

Out of 40 crosses evaluated, none of the cross combination recorded significant positive *sca* effects. Based on *per se* performance and *sca* effects, the cross L 762 × BS 49 (high x low) was found to be superior which may be due to complementary gene action.

4.5.12 Bundle strength (g/tex)

The estimates of *gca* effects were significant and positive for the lines L 804 (0.59**) and L 788 (0.68*) and were found to be good general combiners and can be used in hybridization programmes for improving this trait. All the testers exhibited non-significant *gca* effects.

The proportion of lines (61.50%) had contributed more to the genetic variance as compared to the testers (1.30%) and line x tester (37.20%). The estimated components of variance due to *gca* (0.074**) was lower than *sca* (0.140**). The ratio of general combining ability component of variance to specific combining ability of variance was 0.529, which shows the predominance of non-additive gene action. Thus it can be improved by selecting breeding methods involving selection, inter mating the selected ones in subsequent generations followed by reselection. Heterosis breeding may also be tried to exploit non-additive component. Similar results were earlier reported by Rajanna (2010), Mohan (2011), Haritha *et al.* (2012) and Vineela *et al.* (2012b).

The hybrids, L 762 x GISV 272 (0.56**), NDLH 1938 x CNH 50 (0.51*) and NDLH 1938 x CNH 44 (0.58*) were registered significant positive *sca* effects. The cross combinations, L 804 × CNH 44 (high x low) and L 788 × BS 47 (high x low) were found to be superior as these hybrids exhibited high *per se* performance and *sca* effects. The high x low general combiners indicated the role of additive x non-additive genetic component of variance and superiority resulted may be due to complementary gene action and are likely to throw desirable transgressive segregants.

4.5.13 Uniformity ratio

The estimates of *gca* effects for uniformity ratio were significant and positive for the lines, L 1057 (0.47**) and L 804 (0.27**) and significant and positive for the tester BS 49 (0.81**) which were found to be good general combiners with favourable genes for improving this character.

The proportional contribution of line x tester (58.03%) to the genetic variance was more as compared to lines (18.31%) and testers (23.66%). The estimated components of variance due to *gca* (0.117**) was lower than *sca* (0.401**). The ratio of general combining ability component of variance to specific combining ability of variance was 0.292, which revealed the operation of non-additive gene action. This showed the possibility of improvement of this trait through selection, inter-mating among selected ones reselection besides heterosis breeding. The results are in line with the research findings of Patil *et al.* (2011b), Tulasi *et al.* (2012), Vineela *et al.* (2012b) and Vanaja (2014).

Two crosses showed significant positive *sca* effects viz., L 1060 x CNH 50 (1.19*) and 49 JRP x BS 47 (1.74**). Based on *per se* performance and *sca* effects NDLH 1938 x BS 49 (high high) and L 1057 x BS 49 (high x high) were found to be superior and indicated additive and additive x additive gene action which can be exploited through simple selection procedures.

4.5.14 Seed Cotton Yield per Plant (g)

The estimates of *gca* effects for seed cotton yield per plant were significant and positive for the line NDLH 1938 (36.88**) and for the testers BS 47 (11.13*) and BS 49 (12.38**) which were found to be good general combiners with favourable genes for improving this trait.

The proportional contribution of line x tester (62.49%) to the genetic variance was more as compared to lines (31.56%) and testers (5.95%). The estimated components of variance due to *gca* (77.027*) was lower than *sca* (1262.679**). The ratio of general combining ability component of variance to specific combining ability of variance was 0.061, which revealed the operation of non-additive gene action and breeding methods involving selection, intermating among the selected ones, reselection and heterosis breeding may help to improve this trait. Similar results were earlier reported by Patil *et al.* (2011b), Shinde *et al.* (2012), Vineela *et al.* (2012b), Alkuddsi *et al.* (2013), Nassar (2013) and Vanaja (2014).

Among the 40 crosses only nine crosses showed significant positive *sca* effects viz., L 762 x GISV 272 (33.22**), L 762 x BS 49 (40.88**), L 804 x CNH 44 (41.03**), NDLH 1938 x GISV 272 (51.53**), L 1057 x BS 49 (79.42**), L 1060 x BS 47 (42.93**), 49 JRP x CNH 44 (59.10**), 49 JRP x BS 47 (39.93**) and L 788 x CNH 50 (48.49**). Based on *per se* performance and *sca* effects the crosses, L 1057 x BS 49 (high x high), NDLH 1938 x GISV 272 (high x low) and L 762 x GISV 272 (high x low) were found to be superior. The high x high general combiners indicated the predominance of additive genetic component of variance which can be exploited through simple selection procedures. The high x low general combiners indicated the role of additive x non-additive genetic component of variance and superiority resulted may be due to complementary gene action and are likely to throw desirable transgressive segregants.

4.5.15 Lint Yield per Plant (g)

The estimates of *gca* effects for lint yield per plant were significant and positive for the lines L 762 (5.28**), L 804 (5.80*) and NDLH 1938 (12.31*) and for the tester, BS 49 (5.03**) which were found to be good general combiners.

The proportional contribution of line x tester (60.53%) to the genetic variance was more as compared to lines (34.42%) and testers (5.05%). The estimated components of variance due to *gca* (13.543*) was lower than *sca* (180.671**). The ratio of general combining ability component of variance to specific combining ability of variance was 0.075, which revealed the operation of non-additive gene action and breeding methods involving selection, intermating among the selected ones, reselection and heterosis breeding may help to improve this trait. Similar results were earlier reported by Rajanna (2010), Patel *et al.* (2012), Vineela *et al.* (2012b), Simon *et al.* (2013) and Vanaja (2014).

Out of 40 crosses evaluated, nine crosses viz., L 762 x GISV 272 (19.22**), L 762 x BS 49 (13.25**), L 804 x CNH 44 (16.26**), NDLH 1938 x GISV 272 (19.07**), L 1057 x BS 49 (28.07**), L 1060 x BS 47 (13.05**), 49 JRP x CNH 44 (18.57**), 49 JRP x BS 47 (14.02**) and L 788 x CNH 50 (20.74**) showed significant positive *sca* effects. Based on *per se* performance and *sca* effects the cross L 1057 x BS 49 (high x high), NDLH 1938 x GISV 272 (high x low) and L 762 x GISV 272 (high x low) were found to be superior. The high x high general combiners indicated the predominance of additive genetic component of variance which can be

exploited through simple selection procedures. The high x low general combiners indicated the role of additive x non-additive genetic component of variance and superiority resulted may be due to complementary gene action and are likely to throw desirable transgressive segregants.

The ratio of general combining ability component of variance to specific combining ability components of variance indicated the preponderance of additive gene action for plant height, number of monopodia per plant and micronaire value and non-additive gene action for remaining traits. The traits governed by additive gene action may be exploited through simple selection procedures in recombination breeding or pedigree method of breeding. Whereas, the traits governed by non-additive gene action can be improved through breeding methods involving selection, intermating of selected individuals and reselection besides heterosis breeding.

The combining ability results indicated that the choice of the parents for breeding programme should be based not only on the *per se* performance and *gca* effects but also on *sca* effects of the cross combinations. Parents with good individual performance and good *gca* effects may not nick well, on the other hand, parents with poor *gca* effect may nick well in combination due to complementary gene action.

The cross combinations involving high x high general combiners revealed the additive and additive x additive genetic component of variance where the characters could be easily improved through simple selection procedures in recombination breeding.

The cross combinations involving high x low or low x high general combiners with significant *sca* effects are likely to produce desirable transgressive segregants. These can be studied through biparental mating or diallel selective mating or any other form of recurrent selection in the early generations followed by single plant selection to exploit both additive and non-additive gene actions. The cross combinations involving low x low general combiners may be due to nicking ability/genetic diversity of their parents.

The proportional contribution of line x tester towards the genetic variation was maximum to the characters viz., days to 50% flowering, number of bolls per plant, boll weight, lint index, ginning outturn, 2.5% span length, uniformity ratio, lint yield per plant and seed cotton yield per plant. The lines had shown maximum contribution to the

variability in case of number of sympodia per plant, seed index, micronaire value and bundle strength. Whereas, the testers contributed maximum to the characters plant height and number of monopodia per plant (Table 4.6).

The details of promising parents identified with good general combining ability for different yield and yield components traits were presented in the Table 4.8. Based on *gca* effects among the lines, NDLH 1938 was identified as good general combiner for the characters viz., plant height, number of monopodia per plant, number of sympodia per plant, number of bolls per plant, boll weight, 2.5% span length, lint yield per plant and seed cotton yield per plant and the line L 804 was identified as good general combiner for the characters viz., number of sympodia per plant, lint index, ginning outturn, 2.5% span length, micronaire value, bundle strength and lint yield per plant. Among the testers, BS 49 was identified as good general combiner for the characters viz., plant height, number of monopodia per plant, boll weight, uniformity ratio, lint yield per plant and seed cotton yield per plant followed by the tester CNH 44 for number of monopodia per plant, seed index, lint index and 2.5% span length.

4.6 HETEROSIS

The phenomenon of heterosis has proved to be the most important genetic tool in boosting the yield of self as well as cross pollinated crops and is considered as the most important breakthrough in the field of crop improvement. Shull (1914) coined the term heterosis and it is the phenomenon in which the F_1 of two genetically dissimilar parents show increased vigour for various characters over the mid parent (relative heterosis) or better parent (heterobeltiosis) or the superior check (standard heterosis). Studies on the magnitude of heterosis in F_1 's helps in assessing the ability of the lines (test genotypes) to transmit the desirable characters to the F_1 's upon hybridization. This facilitates in identification of lines that exhibit high amount of exploitable heterosis. It also contributes to choose genotypes with desired genetic variance, vigour and maternal effects.

The character-wise results of relative heterosis, heterobeltiosis and standard heterosis are discussed here under and presented in Tables 4.15 to 4.18. Based on the overall performance (*per se* performance, high *sca* effects and standard heterosis), the best heterotic combinations identified for yield and yield components are presented in the Table 4.19.

4.6.1 Days to 50% Flowering

The mean value of heterosis for days to 50 % flowering over mid parent, better parent and standard check was found to be 3.18, 0.50 and 7.47 per cent respectively. Heterosis over mid parent ranged from -8.00 (49 JRP × CNH 44) to 16.53 (NDLH 1938 × CNH 44), over better parent from -9.55 (49 JRP × CNH 44) to 16.20 (NDLH 1938 × CNH 44) and over standard check from -6.402 (49 JRP × CNH 44) to 20.93 (NDLH 1938 × CNH 44, L1060 × BS 47).

Crosses exhibited significant negative heterosis over mid parent, over better parent and over standard check were four, seven and one, respectively. The best heterotic combinations identified were 49 JRP × CNH 44, 49 JRP × GISV 272 and L804 × CNH 50. Deosarkar *et al.* (2009a) who had reported significant negative heterosis compared to all heterosis.

4.6.2 Plant Height (cm)

Heterosis for plant height over mid parent, better parent and superior check ranged from -2.66 (49 JRP × GISV 272) to 32.08 (L 1060 × BS 49), -5.22 (49 JRP × GISV 272) to 29.15 (L 1060 × BS 49) and -15.55 (49 JRP × GISV 272) to 33.82 (NDLH 1938 × BS 49) with mean value of 16.46, 12.13 and 14.25 per cent, respectively. Thirty six, twenty three, twenty eight crosses had showed positive significant heterosis over mid parent, better parent and superior check, respectively. The top three heterotic cross combinations were, NDLH 1938 × BS 49, L 762 × CNH 50 and L 1060 × BS 49. The results are in agreement with the research findings of Deosarkar *et al.* (2009a), Patel *et al.* (2012), Punitha *et al.* (2012) and Sekhar *et al.* (2012) who had reported significant positive heterosis.

4.6.3 Number of Monopodia per Plant

The mean value of heterosis for number of monopodia per plant over mid parent, better parent and standard check was found to be 36.83, 1.34 and -14.91 respectively. Heterosis over mid parent ranged from -54.72 (L 1060 × BS 47) to 112.24 (L 804 × GISV 272), over better parent -68.42 (L 1060 × BS 47) to 72.50 (L 804 × CNH 44) and over standard check -79.31 (L 1060 × BS 47) to 37.93 (L 762 × CNH 50). Twenty four, eight and seven crosses had showed positive significant heterosis over mid parent, better parent and superior check, respectively. The hybrids viz., L 762

× CNH 50, NDLH 1938 × BS 49, L 762 × CNH 44 exhibited high heterosis over mid parent, better parent and standard check, respectively. These results are in agreement with the research findings of Maisuria *et al.* (2007), Deosarkar *et al.* (2009a) and Sekhar *et al.* (2012) who had reported significant positive heterosis.

4.6.4 Number of Sympodia per Plant

Heterosis over mid parent, better parent and superior check ranged from -16.75 (L 1057 × BS 47) to 20.50 (NDLH 1938 × CNH 50), -19.27 (L 1057 × BS 47) to 19.26 (L 804 × BS 47) and -16.54 (49 JRP × GISV 272) to 19.01 (NDLH 1938 × BS 47) with mean value of 2.56, -2.39 and -2.02, respectively. Nine, one and four crosses had exhibited significant positive heterosis over mid parent, better parent and standard check, respectively. The best heterotic combinations identified were viz., NDLH 1938 × BS 47, L 762 × CNH 50 over mid parent, better parent and standard check. Deosarkar *et al.* (2009a) and Sekhar *et al.* (2012) were also reported similar findings.

4.6.5 Number of Bolls per Plant

The mean value of heterosis for number of bolls per plant over mid parent, better parent and standard check was found to be -1.71, -6.23 and -4.50 respectively. Heterosis over mid parent ranged from -27.27 (L 1057 × GISV 272) to 24.42 (L 762 × BS 49), over better parent -27.27 (L 1057 × GISV 272) to 20.78 (L 804 × CNH 50) and over standard check -33.92 (49 JRP × CNH 50) to 25.15 (L 762 × BS 49). Four crosses over mid parent, three crosses over better parent and two crosses over standard check exhibited significant positive heterosis. L 762 × BS 49, NDLH 1938 × GISV 272, L 762 × GISV 272 were identified as best heterotic combinations over mid parent, over better parent and over standard check. These results are in agreement with the research findings of Pole *et al.* (2008), Deosarkar *et al.* (2009a), Patel *et al.* (2012) and Sekhar *et al.* (2012) who had reported significant positive heterosis.

4.6.6 Boll Weight (g)

The mean value of heterosis for boll weight over mid parent, better parent and standard check was found to be 19.83, 13.48 and 10.63 respectively. Heterosis over mid parent ranged from 1.43 (L 788 × CNH 44) to 33.92 (49 JRP × CNH 44), over better parent -11.80 (L 788 × CNH 44) to 28.10 (L 801 × GISV 272) and over standard check -2.96 (L 762 × CNH 50) to 28.15 (L 1057 × BS 49). Number of crosses exhibited significant positive heterosis over mid parent, better parent and standard check were thirty eight, thirty one and twenty six respectively.

The crosses, L 1057 × BS 49, L 788 × BS 47, L 788 × BS 49 were recorded significant and positive heterosis over mid parent, better parent and standard check. These findings are in support with the reports of Patel *et al.* (2012) and Sekhar *et al.* (2012).

4.6.7 Seed index (g)

Heterosis for seed index over mid parent, better parent and superior check ranged from 95.57 (L 788 × CNH 50) to 217.18 (49 JRP × CNH 44), 64.60 (L 788 × CNH 50) to 205.98 (NDLH 1938 × CNH 50) and 85.19 (L 762 × BS 47) to 166.67 (49 JRP × CNH 44) with mean value of 151.34, 138.27 and 130.82, respectively. All forty crosses exhibited significant positive heterosis over mid parent, better parent and standard check. Crosses viz., 49 JRP × CNH 44, NDLH 1938 × CNH 50 and L 1060 × CNH 50 recorded significant positive heterosis over mid parent, better parent and standard check. Deosarkar *et al.* (2009a) who had reported significant positive heterosis compared to all heterosis.

4.6.8 Lint index (g)

The mean value of heterosis for lint index over mid parent, better parent and standard check was found to be -5.56, -10.40 and -12.04, respectively. Heterosis over mid parent ranged from -26.95 (L 1057 × GISV 272) to 11.01 (L 801 × GISV 272), over better parent it ranged from -33.11 (L 1057 × GISV 272) to 5.17 (49 JRP × GISV 272) and over standard check it ranged from -29.14 (L 762 × BS 47) to 0.38 (L 1060 × CNH 44). Two crosses over mid parent, none of the cross over better parent and standard check exhibited significant positive heterosis. L 1060 × CNH 44, NDLH 1938 × CNH 50 and 49 JRP × GISV 272 were identified as the best heterotic combinations over mid parent, better parent and standard check. These findings are in conformity with the results of Sekhar *et al.* (2012) who reported for all the positive significant heterosis.

4.6.9 Ginning outturn (%)

Heterosis for ginning outturn over mid parent, better parent and superior check ranged from -12.01 (L 801 × BS 47) to 3.96 (L 801 × GISV 272), -12.82 (L 801 × BS 47) to 3.90 (L 801 × GISV 272) and -13.25 (L 801 × BS 47) to 2.65 (L 801 × BS 49) with mean value of -0.98, -1.97 and -2.28, respectively. None of the cross exhibited positive significant heterosis over mid, better parent and standard check.

The hybrids, L 804 × BS 49, L 1060 × BS 47 and L 1057 × BS 47 were recorded non-significant positive heterosis over mid parent, better parent and standard check. These results are in support with the findings of Deosarkar *et al.* (2009a) and Sekhar *et al.* (2012).

4.6.10 2.5% span length (mm)

The mean value of heterosis for 2.5 % span length over mid parent, better parent and standard check was found to be 5.83, 1.97 and 10.24, respectively. Heterosis over mid parent ranged from -10.43 (L 1057 × BS 49) to 15.62 (NDLH 1938 × GISV 272), over better parent it ranged from -11.55 (L 1057 × BS 49) to 12.07 (NDLH 1938 × GISV 272) and over standard check ranged from -0.47 (L 1057 × BS 49) to 18.56 (NDLH 1938 × GISV 272). Thirty two crosses over mid parent, nineteen crosses over better parent and thirty five crosses over standard check exhibited significant positive heterosis. The best heterotic combinations identified were NDLH 1938 × GISV 272, L 788 × BS 47 and 49 JRP × BS 49 over mid, better parent and standard check respectively. These results are in agreement with the findings of Maisuria *et al.* (2007), Rajamani *et al.* (2009), Sekhar *et al.* (2012) and Kumar and Ravikesavan (2013) who reported significant positive heterosis compared to all heterosis.

4.6.11 Micronaire value (10^{-6} g/inch)

Heterosis over mid parent, better parent and superior check ranged from -15.00 (49 JRP × GISV 272) to 9.70 (L 804 × CNH 44), -23.31 (49 JRP × GISV 272) to 4.84 (L 804 × CNH 44) and -19.69 (49 JRP × GISV 272, 49 JRP × BS 47) to 9.45 (L 762 × BS 49) with mean value of 0.36, -3.44 and -4.10 respectively. Crosses exhibited positive significant heterosis over mid parent and standard check were five and two respectively. The best heterotic combinations identified over mid parent, better parent and standard check were L 762 × BS 49, L 762 × GISV 272 and L 762 × CNH 50. These results are in accordance with the research findings of Rajamani *et al.* (2009), Sekhar *et al.* (2012) and Kumar and Ravikesavan (2013) who had reported significant positive heterosis compared to all heterosis.

4.6.12 Bundle strength (g/tex)

The mean value of heterosis over mid parent, better parent and standard check was found to be 0.95, -1.71 and 3.04, respectively. Heterosis over mid parent ranged from -6.61 (NDLH 1938 × BS 47) to 7.21 (L 788 × CNH 50), over better parent -8.80

(L 1060 × BS 47) to 4.59 (L 801 × GISV 272) and over standard check -1.98 (L 1057 × BS 49) to 7.15 (L 804 × CNH 44). Fourteen crosses over mid parent, one cross over better parent and twenty one over standard check exhibited significant positive heterosis. The best heterotic combination identified was L 804 × CNH 44 over mid parent, L 788 × BS 47 over better parent and L 788 × CNH 50 over standard check. These results are in conformity with the reports of Maisuria *et al.* (2007), Sekhar *et al.* (2012) and Kumar and Ravikesavan (2013) who had reported for significant positive heterosis compared to all heterosis.

4.6.13 Uniformity ratio

Heterosis over mid parent, better parent and superior check ranged from -6.57 (49 JRP × GISV 272) to 6.91 (NDLH 1938 × BS 49), -7.53 (49 JRP × GISV 272) to 5.76 (NDLH 1938 × BS 49) and -5.59 (49 JRP × GISV 272) to 2.80 (NDLH 1938 × BS 49) with mean value of 0.33, -0.88 and -1.26 respectively. Six crosses over mid parent, three crosses over better parent exhibited significant positive heterosis. The best heterotic combinations identified were NDLH 1938 × BS 49 over mid parent, L 1057 × BS 49 over better parent and L 762 × BS 49 over standard check.

These results were in agreement with the findings of Maisuria *et al.* (2007), Rajamani *et al.* (2009), Sekhar *et al.* (2012) and Kumar and Ravikesavan (2013) who had reported significant positive heterosis for this trait.

4.6.14 Seed Cotton Yield per Plant (g)

Heterosis over mid parent, better parent and superior check ranged from -17.31 (49 JRP × GISV 272) to 68.46 (L 1057 × BS 49), -25.40 (49 JRP × GISV 272) to 61.16 (L 1057 × BS 49) and -35.82 (49 JRP × CNH 50) to 38.87 (L 1057 × BS 49) with mean value of 13.93, 9.26 and -1.20, respectively. Seventeen crosses over mid parent, twelve crosses over better parent and six crosses over standard check exhibited significant positive heterosis. The best heterotic combinations identified over mid parent, better parent and standard check were L 1057 × BS 49, NDLH 1938 × GISV 272 and L 762 × BS 49. These results are in agreement with the findings of Maisuria *et al.* (2007), Rajamani *et al.* (2009), Deosarkar *et al.* (2009a), Basamma *et al.* (2010), Balu *et al.* (2012) and Sekhar *et al.* (2012) who had reported significant positive heterosis.

4.6.15 Lint Yield per Plant (g)

Heterosis over mid parent, better parent and superior check ranged from -25.58 (49 JRP $\times$ CNH 50) to 68.08 (L 1057 $\times$ BS 49), -26.64 (49 JRP $\times$ CNH 50) to 56.98 (L 1057 $\times$ BS 49) and -42.59 (49 JRP $\times$ CNH 50) to 40.37 (L 1057 $\times$ BS 49) with mean value of 10.76, 5.13 and -3.16 respectively. Seventeen crosses over mid parent, nine crosses over better parent and four crosses over standard check exhibited significant positive heterosis. The cross combinations L 1057 $\times$ BS 49, NDLH 1938 $\times$ GISV 272 and L 762 $\times$ GISV 272 were recorded high heterosis over mid parent, better parent and standard check, respectively. Similar results were earlier reported by Pole *et al.* (2008), Deosarkar *et al.* (2009a), Patel *et al.* (2012) and Sekhar *et al.* (2012).

Thus, in intra-specific crosses significant positive heterosis was observed for all the yield components and quality traits studied. In fact, crosses with negative heterosis for certain characters like days to 50% flowering is desirable since these hybrids are early in duration compared to their parents.

In the present study based on *per se* performance, heterosis and specific combining ability effects the crosses, L 1057 $\times$ BS 49 and NDLH 1938 $\times$ GISV 272 were found to be promising for seed cotton yield per plant and lint yield per plant. These hybrids can be exploited for commercial cultivation after thorough testing in wider environments for further confirmation. These crosses may also be utilized for further exploitation in segregating generations to isolate superior transgressive segregants.

Chapter II

REVIEW OF LITERATURE

The review of work done on cotton (*Gossypium hirsutum* L.) relevant to the present investigation is furnished under the following headings.

2.1 Genetic variability

2.2 Heritability and genetic advance as per cent of mean

2.3 Correlations

2.4 Path analysis

2.5 Combining ability

2.6 Heterosis

2.1 GENETIC VARIABILITY

An insight into the magnitude of variability present in a crop species is of utmost importance as it provides the basis for effective selection. The phenotype of a character is the resultant of interaction between genotype and environment. Partitioning of observed variability into heritable and non-heritable components is essential to get a true indication of the genetic variation of the trait.

The literature on genetic variability studies on cotton is reviewed and presented in the Table 2.1.

2.2 HERITABILITY ($h^2_{(b)}$) and GENETIC ADVANCE (GA) AS PER CENT OF MEAN

Heritability denotes the proportion of phenotypic variance that is due to genotype i.e, heritable.

Heritability measures the relative amounts of the heritable portion of variability, while the genetic advance (GA) helps to measure the amount of progress that could be expected with selection in a character. Hence heritability alone is always not an indication of genetic gain. Therefore estimates of heritability along with the estimates of genetic advance (GA) are more useful in choice of selection methods rather than heritability or genetic advance alone (Johnson *et al.*, 1955). High heritability coupled with high genetic advance indicates that the improvement could be made for a character by simple selection on phenotypic performance because of preponderance of additive genetic components.

The available literature on heritability and genetic advance as per cent of mean, is reviewed and presented in the Table 2.2.

2.3 CORRELATIONS

Plant yield is a complex phenomenon as it is a polygenically inherited trait therefore direct selection is not effective. But, it could be improved through a number of component characters through correlated response which are simple in inheritance and are less subjected to environmental influence. Hence, correlation studies paved a path in order to find out the association between highly heritable and the most economic character which would help the breeder in obtaining improved yields.

Through review of literature on the association between yield and yield components and among the yield components themselves by different scientists in the last two decades indicate either positive (significant or non-significant) or negative (significant or non-significant) correlations. Hence, for simplicity these studies reviewed here in the tabular form.

2.3.1 Association of Component Characters with Seed Cotton Yield

The available literature on the association of component characters with seed cotton yield has been compiled and is presented in the Table 2.3.

2.3.2 Association among the Yield Component Characters

The available literature on the associations among the yield component characters with seed cotton yield is presented in the Table 2.4.

2.4 PATH COEFFICIENT ANALYSIS

The estimation of path coefficients give an exact picture of relative importance of the direct and indirect contribution of the component characters to yield. Path analysis proposed by Dewey and Lu (1959) facilitates the partitioning of the correlation coefficients into direct and indirect effects of various characters on seed cotton yield. Thus correlations in combination with path analysis would give a better insight into the cause and effect relationship between the pairs of characters. The direct and indirect effect of a variable through other characters is either positive or negative in the studies conducted by various researchers.

The literature on direct and indirect effects of fibre quality parameters and other yield components on seed cotton yield are reviewed and presented in the Table 2.5.

2.5 COMBINING ABILITY

The concept of combining ability as a measure of gene action was proposed by Sprague and Tatum in 1942. Combining ability refers to the ability of parents to transmit desirable performance to its hybrid progeny or crosses. Combining ability analysis helps in the evaluation of inbreds in terms of their genetic value and in the selection of suitable parents for hybridization. The superior specific cross combinations are also identified by this technique. The general combining ability is the average performance of a parent/inbred in cross combinations involving a set of other parents/inbreds. It is specific for the set of lines and testing environment, whereas specific combining ability is the extreme performance of a specific cross combination expressed as negative or positive deviation from the population mean (Sprague and Tatum, 1942).

The *gca* effect reflects the breeding value of the parental genotype concerned and selection of genotypes and it help in identifying genotypes to be used for developing superior populations. Specific combining ability effect

represents the non-reliable component of the genotypic value arising due to contribution from dominance deviation and interaction deviation. Hence, *sca* effect is the main cause for superiority of a cross. It is inferred that superiority of the cross cannot be fixed through selection.

The available literature on combining ability studies on cotton is furnished in the Table 2.6.

2.6 HETEROSIS

Shull (1914) first coined the term heterosis and it is the phenomenon in which the F_1 of two genetically dissimilar parents show increased vigour or size for various characters over the mid parent (relative or mid parent heterosis) or over the better parent (heterobeltiosis) or over the superior check. Exploitation of heterosis to increase the yield of agricultural crops has become one of the most important techniques in plant breeding.

The available literature on heterosis over standard check in cotton is summarized and presented in the Table 2.7.

Chapter V

SUMMARY AND CONCLUSIONS

The present investigation was carried out with the prime objective of testing forty intra-specific hybrids involving eight lines and five testers crossed in line $\times$ tester design for their combining ability and to know the gene action involved in the inheritance of different traits of intra-specific hybrids of cotton. Evaluation of forty hybrids, thirteen parents along with one standard check for different traits were carried out at Regional Agricultural Research Station, Lam Farm, Guntur during *kharif*, 2013-14.

Apart from combining ability studies other parameters like mean, variability, heritability, expected genetic advance, heterosis, character association and path coefficient analysis were also studied for different characters *viz.*, days to 50% flowering, plant height (cm), number of monopodia per plant, number of sympodia per plant, number of bolls per plant, boll weight (g), seed index (g), lint index (g), ginning out turn (%), 2.5% span length (mm), micronaire value (10^{-6} g/inch), bundle strength (g/tex), uniformity ratio, seed cotton yield per plant (g) and lint yield per plant (g).

The analysis of variance indicated significant differences among all the genotypes for all the characters studied. The magnitude of difference between PCV and GCV was low for all the traits except for number of sympodia per plant, number of bolls per plant, seed cotton yield per plant and lint yield per plant which revealed the less influence of environment on majority of the traits under study. Wider variability was observed for number of monopodia per plant, number of bolls per plant, boll weight, seed index, seed cotton yield per plant and lint yield per plant which indicated their amenability towards directional selection. Whereas it was narrow for the characters *viz.*, days to 50% flowering, plant height, number of sympodia, lint index, ginning out turn, 2.5% span length, micronaire value, bundle strength and uniformity ratio. This indicates that there is considerable amount of variability for majority of the characters studied.

The estimates of heritability and genetic advance as per cent of mean were high for the characters *viz.*, number of monopodia per plant, boll weight, seed index, seed cotton yield per plant and lint yield per plant indicating the role of additive gene action

in controlling the inheritance of these traits. High heritability coupled with moderate genetic advance as per cent of mean was observed for days to 50% flowering, plant height, number of sympodia per plant, lint index, micronaire value and 2.5% span length. High heritability coupled with low genetic advance as per cent of mean was observed for bundle strength indicating the role of non-additive gene action. Moderate heritability and moderate genetic advance as percent of mean were recorded for number of bolls per plant revealing the role of additive and non-additive gene action. Moderate heritability coupled with low genetic advance as per cent of mean was registered for ginning out turn and uniformity ratio indicating the operation of non-additive gene action.

The genotypic correlations were higher than the phenotypic correlations and thus suggested that the observed relationships among the characters were due to genetic causes. The characters viz., plant height, number of sympodia per plant, number of bolls per plant, boll weight, seed index, ginning out-turn, micronaire value and lint yield per plant showed highly significant positive correlation with seed cotton yield per plant both at phenotypic and genotypic levels. 2.5 % span length and bundle strength were exhibited negative correlation with seed cotton yield per plant both at phenotypic and genotypic levels. So while making simultaneous selections for improvement of seed cotton yield with desired fiber quality a compromise has to be struck at the level of improvement with regard to the traits having negative association.

The path analysis indicated that plant height, seed index, lint index and lint yield per plant showed direct positive effects and significant correlation with seed cotton yield per plant. The present study revealed that the major emphasis should be laid on selection process with these traits without sacrificing desirable fibre qualities by adopting restriction selection model. However, care should be exercised in developing varieties with desirable fiber quality matching the needs of textile industry since some of the important yield attributes were found negatively associated with important fiber quality parameters and also among themselves.

The analysis of variance for combining ability revealed that the lines had significant amount of variability for the characters viz., plant height, number of monopodia per plant, number of sympodia per plant, boll weight, seed index, micronaire value and bundle strength and the testers for days to 50% flowering, plant height, number of monopodia per plant and uniformity ratio. The variance due to crosses was significant for all the traits and due to line x tester effect was significant for

all the characters studied except for micronaire value. The proportional contribution of line $\times$ tester component had maximum share of genetic variance for the characters days to 50% flowering, number of bolls per plant, boll weight, lint index, ginning out-turn, 2.5% span length, uniformity ratio, lint yield per plant and seed cotton yield per plant. The ratio between *gca* and *sca* variances revealed the role of non-additive gene action in governing all the traits except for plant height, number of monopodia per plant and micronaire value. Hence these characters may be improved by selecting breeding procedures like recurrent selection, intermating selects and reselection.

Out of the eight lines tested in the present investigation, NDLH 1938 recorded significant general combining ability effects in desirable direction for characters plant height, number of monopodia per plant, number of sympodia per plant, number of bolls per plant, boll weight, 2.5% span length, lint yield per plant and seed cotton yield per plant followed by L 804 for the characters number of sympodia per plant, lint index, ginning out-turn, 2.5% span length, micronaire, bundle strength and lint yield per plant. Among the testers, BS 49 was identified as good general combiner for the characters viz., plant height, number of monopodia per plant, boll weight, uniformity ratio, lint yield per plant and seed cotton yield per plant followed by the tester CNH 44 for number of monopodia per plant, seed index, lint index and 2.5% span length. The perusal of *sca* effects revealed that the crosses, L 1057 $\times$ BS 49, NDLH 1938 $\times$ GISV 272 and L 762 $\times$ GISV 272 registered high *sca* effects along with high *per se* performance for seed cotton yield per plant and its component traits. The *gca* effects of parents and *sca* effects of their hybrid combinations indicated that the crosses with high *sca* effects have resulted due to high $\times$ low, low $\times$ low and high $\times$ high *gca* combinations. Therefore, one can afford to include some low general combiners along with good general combiners in hybridization programmes.

Further, superiority of crosses was tested over standard check (LAHH 5) for all the traits. Based on overall performance the crosses, L 1057 $\times$ BS 49 and NDLH 1938 $\times$ GISV 272 were found to be promising for seed cotton yield per plant. The results also suggested that these crosses did not express high heterosis for all the yield component traits studied. However, high heterosis observed for some or a few component traits which are ultimately associated with yield might have contributed towards significant yield heterosis. These hybrids may be used for commercial cultivation after thorough testing over large number of environments. The cross combinations involving high $\times$ high general combiners producing crosses with significant *sca* effect revealed the role

of additive and additive $\times$ additive genetic component of variance which could be easily improved through simple selection procedures. The crosses between high $\times$ low or low $\times$ high *gca* combiners resulted in superior cross combinations due to better nicking ability. These crosses may be exploited by heterosis breeding i.e production of hybrids.

Table 2.1. Review of literature on genetic variability in cotton (*Gossypium hirsutum* L.)

S.No.	Character	Wider genetic variability	Narrow genetic variability
1.	Days to 50% flowering	Neelima <i>et al.</i> (2005) Pujer <i>et al.</i> (2014)	Narisireddy and Ratnakumari (2004) Raju (2005) Kaushik and Kapoor (2006) Pratap (2006) Vijayalaxmi (2007) Rajanna (2010) Sarada <i>et al.</i> (2010) Kulkarni <i>et al.</i> (2011) Haritha <i>et al.</i> (2012) Venkatesh (2012) Anitha (2013) Vineela <i>et al.</i> (2013) Dhivya <i>et al.</i> (2014) Rajamani <i>et al.</i> (2015)
2.	Plant height (cm)	Patnaik <i>et al.</i> (2004) Neelima <i>et al.</i> (2005) Tuteja <i>et al.</i> (2006) Kalpande <i>et al.</i> (2008) Rao <i>et al.</i> (2009b) Sarada <i>et al.</i> (2010) Venkatesh (2012) Anitha (2013) Ranganatha <i>et al.</i> (2013) Vineela <i>et al.</i> (2013) Dhivya <i>et al.</i> (2014)	Kaushik and Kapoor (2006) Pratap (2006) Kale <i>et al.</i> (2007) Vijayalaxmi (2007) Rao (2008) Rajanna (2010) Kulkarni <i>et al.</i> (2011) Haritha <i>et al.</i> (2012) Ahsan <i>et al.</i> (2015) Rajamani <i>et al.</i> (2015)
3.	Number of monopodia per plant	Sivaprasad <i>et al.</i> (2004b) Raju (2005) Kaushik and Kapoor (2006) Verma <i>et al.</i> (2006) Vijayalaxmi (2007) Neelima <i>et al.</i> (2008) Rao (2008) Rajanna (2010) Kishore <i>et al.</i> (2011) Kulkarni <i>et al.</i> (2011) Mohan (2011) Venkatesh (2012) Anitha (2013) Vineela <i>et al.</i> (2013) Rajamani <i>et al.</i> (2015)	Haritha <i>et al.</i> (2012) Pujer <i>et al.</i> (2014)

Table 2.1 (cont..)

S.No.	Character	Wider genetic variability	Narrow genetic variability
4.	Number of sympodia per plant	Kaushik and Kapoor (2006) Gitte <i>et al.</i> (2007) Neelima <i>et al.</i> (2008) Kulkarni <i>et al.</i> (2011) Santoshkumar <i>et al.</i> (2012) Venkatesh (2012) Anitha (2013) Vineela <i>et al.</i> (2013) Dhivya <i>et al.</i> (2014)	Vijayalaxmi <i>et al.</i> (2008) Rajamani <i>et al.</i> (2009) Rao <i>et al.</i> (2009b) Bazi (2011) Haritha <i>et al.</i> (2012)
5.	Number of bolls per plant	Narisireddy and Ratnakumari (2004) Sivaprasad <i>et al.</i> (2004b) Neelima <i>et al.</i> (2005) Kaushik and Kapoor (2006) Neelima <i>et al.</i> (2008) Bazi (2011) Natera <i>et al.</i> (2012) Santoshkumar <i>et al.</i> (2012) Venkatesh (2012) Anitha (2013) Ranganatha <i>et al.</i> (2013) Rao and Gopinath (2013) Vineela <i>et al.</i> (2013) Dhivya <i>et al.</i> (2014) Rajamani <i>et al.</i> (2015)	Pratap (2006) Vijayalaxmi (2007) Vijayalaxmi <i>et al.</i> (2008) Rajamani <i>et al.</i> (2009) Srinivasulu <i>et al.</i> (2010a) Venkateswarulu <i>et al.</i> (2010a) Haritha (2011)
6.	Boll weight (g)	Gururajan and Sundar (2004) Sivaprasad <i>et al.</i> (2004b) Tuteja <i>et al.</i> (2006) Gitte <i>et al.</i> (2007) Kale <i>et al.</i> (2007) Kalpande <i>et al.</i> (2008) Rajamani <i>et al.</i> (2009) Srinivasulu <i>et al.</i> (2010a) Haritha (2011) Kulkarni <i>et al.</i> (2011) Venkatesh (2012) Anitha (2013) Ranganatha <i>et al.</i> (2013) Rao and Gopinath (2013) Vineela <i>et al.</i> (2013) Ahsan <i>et al.</i> (2015)	Vijayalaxmi (2007) Neelima <i>et al.</i> (2008) Vijayalaxmi <i>et al.</i> (2008) Rajanna (2010) Bazi (2011) Dhivya <i>et al.</i> (2014)

Table 2.1 (cont..)

S.No.	Character	Wider genetic variability	Narrow genetic variability
7.	Seed index (g)	Gururajan and Sundar (2004) Kumar (2004) Patnaik <i>et al.</i> (2004) Sivaprasad <i>et al.</i> (2004b) Kaushik and Kapoor (2006) Venkateswarulu <i>et al.</i> (2010a) Kishore <i>et al.</i> (2011) Vineela (2011) Choudki <i>et al.</i> (2012) Anitha (2013) Dhivya <i>et al.</i> (2014)	Vijayalaxmi (2007) Neelima <i>et al.</i> (2008) Mahantesh (2009) Srinivasulu (2009) Rajanna (2010) Bazi (2011) Haritha <i>et al.</i> (2012) Venkatesh (2012)
8.	Lint index (g)	Gururajan and Sundar (2004) Patnaik <i>et al.</i> (2004) Sivaprasad <i>et al.</i> (2004b) Kaushik and Kapoor (2006) Kishore <i>et al.</i> (2011) Kulkarni <i>et al.</i> (2011) Vineela (2011) Choudki <i>et al.</i> (2012) Anitha (2013) Dhivya <i>et al.</i> (2014)	Vijayalaxmi (2007) Neelima <i>et al.</i> (2008) Rao <i>et al.</i> (2009b)
9.	Ginning outturn (%)	Neelima <i>et al.</i> (2005) Tuteja <i>et al.</i> (2006) Rao <i>et al.</i> (2009b) Srinivasulu (2009) Naqib <i>et al.</i> (2010) Venkateswarulu <i>et al.</i> (2010a) Rao and Gopinath (2013)	Kaushik and Kapoor (2006) Vijayalaxmi (2007) Mahantesh (2009) Rajanna (2010) Sarada <i>et al.</i> (2010) Mohan (2011) Vineela (2011) Haritha <i>et al.</i> (2012) Venkatesh (2012) Anitha (2013) Dhivya <i>et al.</i> (2014) Pujer <i>et al.</i> (2014)

Table 2.1 (cont..)

S.No.	Character	Wider genetic variability	Narrow genetic variability
10.	2.5% span length (mm)	Gururajan and Sundar (2004) Naphade <i>et al.</i> (2004) Patnaik <i>et al.</i> (2004) Kale <i>et al.</i> (2007) Rajamani <i>et al.</i> (2009) Rao <i>et al.</i> (2009b) Venkateswarulu <i>et al.</i> (2010a)	Neelima <i>et al.</i> (2005) Kaushik and Kapoor (2006) Pratap (2006) Verma <i>et al.</i> (2006) Vijayalaxmi (2007) Srinivasulu (2009) Rajanna (2010) Vineela (2011) Choudki <i>et al.</i> (2012) Haritha <i>et al.</i> (2012) Natera <i>et al.</i> (2012) Venkatesh (2012) Anitha (2013) Rao and Gopinath (2013) Dhivya <i>et al.</i> (2014) Asha <i>et al.</i> (2015)
11.	Micronaire value (10 ⁻⁶ g/inch)	Naphade <i>et al.</i> (2004) Patnaik <i>et al.</i> (2004) Neelima <i>et al.</i> (2005) Rao <i>et al.</i> (2009b) Kulkarni <i>et al.</i> (2011) Choudki <i>et al.</i> (2012) Anitha (2013)	Kaushik and Kapoor (2006) An <i>et al.</i> (2008) Srinivasulu (2009) Rajanna (2010) Bazi (2011) Vineela (2011) Haritha <i>et al.</i> (2012) Natera <i>et al.</i> (2012) Venkatesh (2012) Rao and Gopinath (2013) Pujer <i>et al.</i> (2014) Asha <i>et al.</i> (2015)
12.	Bundle strength (g/tex)	Gururajan and Sundar (2004) Naphade <i>et al.</i> (2004) Patnaik <i>et al.</i> (2004) Neelima <i>et al.</i> (2005) Rajamani <i>et al.</i> (2009) Rao <i>et al.</i> (2009b) Kulkarni <i>et al.</i> (2011)	Srinivasulu (2009) Rajanna (2010) Srinivasulu <i>et al.</i> (2010a) Bazi (2011) Vineela (2011) Haritha <i>et al.</i> (2012) Venkatesh (2012) Anitha (2013) Rao and Gopinath (2013) Pujer <i>et al.</i> (2014) Asha <i>et al.</i> (2015)

Table 2.1 (cont..)

S.No.	Character	Wider genetic variability	Narrow genetic variability
13.	Uniformity ratio	Neelima <i>et al.</i> (2005)	Muraleedhar (2005) Vijayalaxmi (2007) Neelima <i>et al.</i> (2008) Rajanna (2010) Bazi (2011) Vineela (2011) Haritha <i>et al.</i> (2012) Natera <i>et al.</i> (2012) Venkatesh (2012) Anitha (2013) Rao and Gopinath (2013) Pujer <i>et al.</i> (2014) Asha <i>et al.</i> (2015)
14.	Seed cotton yield per plant (g)	Narisireddy and Ratnakumari (2004) Kaushik and Kapoor (2006) Pratap (2006) Vijayalaxmi (2007) Srinivasulu (2009) Naqib <i>et al.</i> (2010) Kishore <i>et al.</i> (2011) Kulkarni <i>et al.</i> (2011) Haritha (2011) Mohan (2011) Choudki <i>et al.</i> (2012) Natera <i>et al.</i> (2012) Santoshkumar <i>et al.</i> (2012) Venkatesh (2012) Anitha (2013) Ranganatha <i>et al.</i> (2013) Rao and Gopinath (2013) Dhivya <i>et al.</i> (2014) Pujer <i>et al.</i> (2014) Ahsan <i>et al.</i> (2015)	An <i>et al.</i> (2008) Mahantesh (2009) Rao <i>et al.</i> (2009b) Rajanna (2010) Srinivasulu <i>et al.</i> (2010a) Bazi (2011) Vineela (2011)
15.	Lint yield per plant (g)	Pratap (2006) Vijayalaxmi (2007) Patil (2010) Vineela (2011) Natera <i>et al.</i> (2012) Venkatesh (2012) Rao and Gopinath (2013)	Mahantesh (2009) Rajanna (2010)

Table 2.2. Review of literature on heritability ($h^2_{(b)}$) and genetic advance (GA) in cotton (*Gossypium hirsutum* L.)

S. No.	Character	High heritability and high genetic advance	High heritability and low genetic advance	Low heritability and high genetic advance	Low heritability and low genetic advance
1.	Days to 50% flowering	Batool <i>et al.</i> (2010)	Muraleedhar (2005) Kaushik and Kapoor (2006) Kale <i>et al.</i> (2007) Ravikesavan <i>et al.</i> (2008) Mahantesh (2009) Rajanna (2010) Haritha (2011) Kulkarni <i>et al.</i> (2011) Vineela <i>et al.</i> (2013) Dhivya <i>et al.</i> (2014)	Vijayalaxmi (2007)	Rao (2008) Kulakarni <i>et al.</i> (2010)
2.	Plant height (cm)	Roy (2006) Kale <i>et al.</i> (2007) Sakthi <i>et al.</i> (2007) Ravikesavan <i>et al.</i> (2008) Muhammad <i>et al.</i> (2009) Sabir <i>et al.</i> (2010) Kulkarni <i>et al.</i> (2011) Haritha <i>et al.</i> (2012) Ranganatha <i>et al.</i> (2013) Vineela <i>et al.</i> (2013) Dhivya <i>et al.</i> (2014) Erande <i>et al.</i> (2014) Ahsan <i>et al.</i> (2015)	Kaushik and Kapoor (2006) Verma <i>et al.</i> (2006) Vijayalaxmi (2007) Mahantesh (2009)	-	Rao (2008) Rajanna (2010)

Table 2.2 (cont..)

S.No.	Character	High heritability and high genetic advance	High heritability and low genetic advance	Low heritability and high genetic advance	Low heritability and low genetic advance
3.	Number of monopodia per plant	Raju (2005) Kaushik and Kapoor (2006) Pratap (2006) Vijayalaxmi (2007) Abbas <i>et al.</i> (2008) Muhammad <i>et al.</i> (2009) Haritha (2011) Vineela <i>et al.</i> (2013) Erande <i>et al.</i> (2014) Vanaja (2014)	Kulakarni <i>et al.</i> (2010)	Sivaprasad <i>et al.</i> (2004a)	Kale <i>et al.</i> (2007) Rao and Rajamani (2009) Rajanna (2010)
4.	Number of sympodia per plant	Verma <i>et al.</i> (2006) Sakthi <i>et al.</i> (2007) Ravikesavan <i>et al.</i> (2008) Muhammad <i>et al.</i> (2009) Rajanna (2010) Bazi (2011) Haritha <i>et al.</i> (2012) Vineela <i>et al.</i> (2013) Dhivya <i>et al.</i> (2014) Erande <i>et al.</i> (2014) Rajamani <i>et al.</i> (2015)	Vijayalaxmi (2007) Srinivasulu (2009) Muhammad <i>et al.</i> (2010) Kulkarni <i>et al.</i> (2011)	Mahantesh (2009)	Sivaprasad <i>et al.</i> (2004a) Ahmed <i>et al.</i> (2006) Murthy <i>et al.</i> (2006) Rao and Rajamani (2009) Bazi (2011)

Table 2.2 (cont..)

S.No.	Character	High heritability and high genetic advance	High heritability and low genetic advance	Low heritability and high genetic advance	Low heritability and low genetic advance
5.	Number of bolls per plant	Sivaprasad <i>et al.</i> (2004a) Pratap (2006) Roy (2006) Kale <i>et al.</i> (2007) Manzoor <i>et al.</i> (2009) Muhammad <i>et al.</i> (2009) Rajanna (2010) Bazi (2011) Iqbal <i>et al.</i> (2011) Ranganatha <i>et al.</i> (2013) Rao and Gopinath (2013) Vineela <i>et al.</i> (2013) Dhivya <i>et al.</i> (2014) Erande <i>et al.</i> (2014) Rajamani <i>et al.</i> (2015)	Gururajan and Sundar (2004) Muhammad <i>et al.</i> (2010)	Lu and Myers (2011)	Rao and Rajamani (2009)
6.	Boll weight (g)	Narisireddy and Ratnakumari (2004) Raju (2005) Sakthi <i>et al.</i> (2007) Abbas <i>et al.</i> (2008) Manzoor <i>et al.</i> (2009) Muhammad <i>et al.</i> (2010) Patnaik and Sial (2010) Iqbal <i>et al.</i> (2011) Haritha <i>et al.</i> (2012) Santoshkumar <i>et al.</i> (2012) Ranganatha <i>et al.</i> (2013) Rao and Gopinath (2013)	Gururajan and Sundar (2004) Hafiz <i>et al.</i> (2006) Kale <i>et al.</i> (2007) Lu and Myers (2011)	Sivaprasad <i>et al.</i> (2004a) Dhivya <i>et al.</i> (2014)	Rao and Rajamani (2009)

Table 2.2 (cont..)

S. No.	Character	High heritability and high genetic advance	High heritability and low genetic advance	Low heritability and high genetic advance	Low heritability and low genetic advance
6.	Boll weight (g)	Vineela <i>et al.</i> (2013) Erande <i>et al.</i> (2014) Ahsan <i>et al.</i> (2015) Rajamani <i>et al.</i> (2015)	-	-	-
7.	Seed index (g)	Kaushik and Kapoor (2006) Ravikesavan <i>et al.</i> (2008) Naqib <i>et al.</i> (2010) Haritha (2011) Lu and Myers (2011) Vineela <i>et al.</i> (2013) Dhivya <i>et al.</i> (2014) Ahsan <i>et al.</i> (2015) Rajamani <i>et al.</i> (2015)	Sivaprasad <i>et al.</i> (2004a) Sakthi <i>et al.</i> (2007) Kulkarni <i>et al.</i> (2010) Rajanna (2010)	Choudki <i>et al.</i> (2012)	Gururajan and Sundar (2004) Srinivasulu (2009)
8.	Lint index (g)	Raju (2005) Murthy <i>et al.</i> (2006) Vijayalaxmi (2007) Ravikesavan <i>et al.</i> (2008) Naqib <i>et al.</i> (2010) Lu and Myers (2011)	Sakthi <i>et al.</i> (2007) Rajanna (2010) Kulakarni <i>et al.</i> (2010)	-	Srinivasulu (2009)

Table 2.2 (cont..)

S. No.	Character	High heritability and high genetic advance	High heritability and low genetic advance	Low heritability and high genetic advance	Low heritability and low genetic advance
8.	Lint index (g)	Haritha <i>et al.</i> (2012) Santoshkumar <i>et al.</i> (2012) Vineela <i>et al.</i> (2013) Dhivya <i>et al.</i> (2014)	-	-	-
9.	Ginning outturn (%)	Gururajan and Sundar (2004) Ravikesavan <i>et al.</i> (2008) Haritha <i>et al.</i> (2012) Rao and Gopinath (2013) Vineela <i>et al.</i> (2013)	Raju (2005) Pratap (2006) Verma <i>et al.</i> (2006) Kale <i>et al.</i> (2007) Vijayalaxmi (2007) Rajanna (2010) Bazi (2011) Dhivya <i>et al.</i> (2014) Rajamani <i>et al.</i> (2015)	Choudki <i>et al.</i> (2012)	Sivaprasad <i>et al.</i> (2004a) Murthy <i>et al.</i> (2006) Srinivasulu (2009) Choudki <i>et al.</i> (2012)
10.	2.5% span length (mm)	Gururajan and Sundar (2004) Bazi (2011) Rao and Gopinath (2013) Dhivya <i>et al.</i> (2014) Erande <i>et al.</i> (2014) Rajamani <i>et al.</i> (2015)	Kaushik and Kapoor (2006) Verma <i>et al.</i> (2006) Kale <i>et al.</i> (2007) Sakthi <i>et al.</i> (2007) Vijayalaxmi (2007) Ravikesavan <i>et al.</i> (2008) Rajanna (2010) Choudki <i>et al.</i> (2012) Vineela <i>et al.</i> (2013)	-	Haritha (2011)
11.	Micronaire value (10 ⁻⁶ g/inch)	Abbas <i>et al.</i> (2008) Muhammad <i>et al.</i> (2008) Ravikesavan <i>et al.</i> (2008) Muhammad <i>et al.</i> (2010) Bazi (2011)	Hafiz <i>et al.</i> (2006) Sakthi <i>et al.</i> (2007) Vijayalaxmi (2007) Mahantesh (2009)	Choudki <i>et al.</i> (2012)	Sivaprasad <i>et al.</i> (2004a) Rao and Rajamani (2009) Srinivasulu (2009) Rajanna (2010)

Table 2.2 (cont..)

S. No.	Character	High heritability and high genetic advance	High heritability and low genetic advance	Low heritability and high genetic advance	Low heritability and low genetic advance
11.	Micronaire value (10 ⁻⁶ g/inch)	Haritha (2011) Rao and Gopinath (2013) Vineela <i>et al.</i> (2013) Rajamani <i>et al.</i> (2015)	-	-	-
12.	Bundle strength (g/tex)	Murthy <i>et al.</i> (2006) Abbas <i>et al.</i> (2008) Muhammad <i>et al.</i> (2008) Ravikesavan <i>et al.</i> (2008) Muhammad <i>et al.</i> (2009) Iqbal <i>et al.</i> (2011) Rao and Gopinath (2013)	Sakthi <i>et al.</i> (2007) Muhammad <i>et al.</i> (2010) Rajanna (2010) Haritha (2011) Kulkarni <i>et al.</i> (2011) Choudki <i>et al.</i> (2012) Vineela <i>et al.</i> (2013) Vanaja (2014)	-	Gururajan and Sundar (2004) Sivaprasad <i>et al.</i> (2004a) Muraleedhar (2005) Vijayalaxmi (2007) Rao (2008) Mahantesh (2009) Rao and Rajamani (2009) Bazi (2011)
13.	Uniformity ratio	Muhammad <i>et al.</i> (2008) Haritha (2011)	Sakthi <i>et al.</i> (2007) Bazi (2011) Rao and Gopinath (2013) Vineela <i>et al.</i> (2013) Rajamani <i>et al.</i> (2015)	Raju (2005)	Sivaprasad <i>et al.</i> (2004a) Muraleedhar (2005) Vijayalaxmi (2007) Rajanna (2010) Choudki <i>et al.</i> (2012) Rao and Gopinath (2013)

Table 2.2 (cont..)

S. No.	Character	High heritability and high genetic advance	High heritability and low genetic advance	Low heritability and high genetic advance	Low heritability and low genetic advance
14.	Seed cotton yield per plant (g)	Sivaprasad <i>et al.</i> (2004a) Kaushik and Kapoor (2006) Abbas <i>et al.</i> (2008) Manzoor <i>et al.</i> (2009) Patnaik and Sial (2010) Iqbal <i>et al.</i> (2011) Choudki <i>et al.</i> (2012) Haritha <i>et al.</i> (2012) Ranganatha <i>et al.</i> (2013) Rao and Gopinath (2013) Vineela <i>et al.</i> (2013) Dhivya <i>et al.</i> (2014) Erande <i>et al.</i> (2014) Vanaja (2014) Ahsan <i>et al.</i> (2015)	Gururajan and Sundar (2004) Kale <i>et al.</i> (2007)	-	Rao and Rajamani (2009)
15.	Lint yield per plant (g)	Pratap (2006) Gamal <i>et al.</i> (2009) Muhammad <i>et al.</i> (2010) Rajanna (2010) Iqbal <i>et al.</i> (2011) Lu and Myers (2011) Venkatesh (2012) Rao and Gopinath (2013) Vineela <i>et al.</i> (2013) Erande <i>et al.</i> (2014)	Abbas <i>et al.</i> (2008) Muhammad <i>et al.</i> (2009)	-	-

Table 2.4. Review of literature on association among the seed cotton yield components in cotton (*Gossypium hirsutum* L.)

S. No	Character	Association	S/NS	Reference
I. Days to 50% flowering with				
1.	Plant height	Positive	S	Mahantesh (2009) Kumar and Ravikesavan (2010) Vineela (2011) Venkatesh (2012)
		Negative	S	An <i>et al.</i> (2008) Vijayalaxmi <i>et al.</i> (2008) Rajanna <i>et al.</i> (2011) Asha <i>et al.</i> (2015)
			NS	Sakthi <i>et al.</i> (2007) Rao (2008) Rajanna (2010) Anitha (2013) Rajamani <i>et al.</i> (2013) Pujer <i>et al.</i> (2014) Reddy <i>et al.</i> (2015)
2.	Number of monopodia per plant	Positive	S	Muraleedhar (2005) Raju (2005) Iqbal <i>et al.</i> (2006) Kaushik and Kapoor (2006) Vijayalaxmi <i>et al.</i> (2008) Mahantesh <i>et al.</i> (2010) Vineela (2011) Alkuddsi <i>et al.</i> (2013)
			NS	Srinivasulu (2009) Venkateswarulu <i>et al.</i> (2010b) Pujer <i>et al.</i> (2014)
		Negative	S	Rajanna <i>et al.</i> (2011) Venkatesh (2012) Rajamani <i>et al.</i> (2013)
			NS	Annapurve <i>et al.</i> (2007) Kale <i>et al.</i> (2007) Rajanna (2010) Anitha (2013) Asha <i>et al.</i> (2015)

Table 2.4 (cont.)

S. No.	Character	Association	S/NS	Reference
3.	Number of sympodia per plant	Positive	S	Muraleedhar (2005) Kumar <i>et al.</i> (2010) Kumar and Ravikesavan (2010) Mahantesh <i>et al.</i> (2010) Shazia <i>et al.</i> (2010) Venkateswarulu <i>et al.</i> (2010b) Haritha (2011) Venkatesh (2012)
			NS	Anandan (2009) Vineela (2011)
		Negative	S	Raju (2005) Vijayalaxmi <i>et al.</i> (2008) Rajamani <i>et al.</i> (2013) Reddy <i>et al.</i> (2015)
			NS	Kaushik and Kapoor (2006) Annapurve <i>et al.</i> (2007) Kale <i>et al.</i> (2007) Sakthi <i>et al.</i> (2007) Rajanna <i>et al.</i> (2011) Alkuddsi <i>et al.</i> (2013) Anitha (2013)
4.	Number of bolls per plant	Positive	S	Muraleedhar (2005) Pratap <i>et al.</i> (2007) An <i>et al.</i> (2008) Vijayalaxmi <i>et al.</i> (2008) Mahantesh (2009) Rao and Rajamani (2009) Shazia <i>et al.</i> (2010) Bazi (2011) Venkatesh (2012)
			NS	Kaushik and Kapoor (2006) Kale <i>et al.</i> (2007) Rajanna <i>et al.</i> (2011) Pujer <i>et al.</i> (2014)
		Negative	S	Vineela (2011) Anitha (2013) Alkuddsi <i>et al.</i> (2013) Rajamani <i>et al.</i> (2013) Asha <i>et al.</i> (2015)
			NS	Raju (2005) Annapurve <i>et al.</i> (2007) Sakthi <i>et al.</i> (2007) Srinivasulu (2009) Venkateswarulu <i>et al.</i> (2010b)

Table 2.4 (cont.)

S. No.	Character	Association	S/NS	Reference
5.	Boll weight	Positive	S	An <i>et al.</i> (2008) Kumar <i>et al.</i> (2010) Kumar and Ravikesavan (2010) Shazia <i>et al.</i> (2010) Bazi (2011) Vineela (2011) Reddy <i>et al.</i> (2015)
			NS	Alkuddsi <i>et al.</i> (2013)
		Negative	S	Muraleedhar (2005) Raju (2005) Pratap <i>et al.</i> (2007) Venkateswarulu <i>et al.</i> (2010b) Rajanna <i>et al.</i> (2011) Anitha (2013) Rajamani <i>et al.</i> (2013)
			NS	Sakthi <i>et al.</i> (2007) Annapurve <i>et al.</i> (2007) Anandan (2009) Rao <i>et al.</i> (2009a) Pujer <i>et al.</i> (2014)
6.	Seed index	Positive	S	Raju (2005) Pratap <i>et al.</i> (2007) An <i>et al.</i> (2008) Rao <i>et al.</i> (2009a) Mahantesh (2009) Kumar <i>et al.</i> (2010) Bazi (2011) Haritha (2011) Vineela (2011) Venkatesh (2012)
			NS	Kale <i>et al.</i> (2007) Rao (2008) Alkuddsi <i>et al.</i> (2013) Anitha (2013) Rajamani <i>et al.</i> (2013) Asha <i>et al.</i> (2015)
		Negative	S	Muraleedhar (2005) Vijayalaxmi <i>et al.</i> (2008) Rajanna <i>et al.</i> (2011) Pujer <i>et al.</i> (2014)

Table 2.4 (cont.)

S. No.	Character	Association	S/NS	Reference
6.	Seed index	Negative	NS	Kaushik and Kapoor (2006) Srinivasulu (2009) Rajanna (2010) Venkateswarulu <i>et al.</i> (2010b)
7.	Lint index	Positive	S	Raju (2005) An <i>et al.</i> (2008) Kumar <i>et al.</i> (2010) Mahantesh <i>et al.</i> (2010) Bazi (2011) Vineela (2011) Reddy <i>et al.</i> (2015)
			NS	Anandan (2009) Rao <i>et al.</i> (2009a) Anitha (2013)
		Negative	S	Kaushik and Kapoor (2006) Pratap <i>et al.</i> (2007) Sakthi <i>et al.</i> (2007) Vijayalaxmi <i>et al.</i> (2008) Rajanna <i>et al.</i> (2011) Rajamani <i>et al.</i> (2013) Pujer <i>et al.</i> (2014)
			NS	Srinivasulu (2009) Rajanna (2010) Venkateswarulu <i>et al.</i> (2010b) Alkuddsi <i>et al.</i> (2013)
8.	Ginning outturn	Positive	S	Raju (2005) Annapurve <i>et al.</i> (2007) Kale <i>et al.</i> (2007) Kumar <i>et al.</i> (2010) Kumar and Ravikesavan (2010) Shazia <i>et al.</i> (2010) Reddy <i>et al.</i> (2015)
			NS	Kaushik and Kapoor (2006) Rao (2008) Vijayalaxmi <i>et al.</i> (2008) Rajanna (2010) Vineela (2011)
		Negative	S	Pratap <i>et al.</i> (2007) Alkuddsi <i>et al.</i> (2013) Anitha (2013) Rajamani <i>et al.</i> (2013)
			NS	Iqbal <i>et al.</i> (2006) Annapurve <i>et al.</i> (2007) Sakthi <i>et al.</i> (2007)

Table 2.4 (cont.)

S. No.	Character	Association	S/NS	Reference
8.	Ginning out-turn	Negative	NS	Kale <i>et al.</i> (2007) Rao <i>et al.</i> (2009a) Venkateswarulu <i>et al.</i> (2010b) Rajanna <i>et al.</i> (2011) Pujer <i>et al.</i> (2014)
9.	2.5% span length	Positive	S	Muraleedhar (2005) An <i>et al.</i> (2008) Kumar and Ravikesavan (2010) Venkatesh (2012)
			NS	Raju (2005) Vijayalaxmi <i>et al.</i> (2008) Rao <i>et al.</i> (2009a) Mahantesh <i>et al.</i> (2010) Vineela (2011) Anitha (2013) Rajamani <i>et al.</i> (2013) Reddy <i>et al.</i> (2015)
		Negative	S	Venkateswarulu <i>et al.</i> (2010b)
			NS	Kaushik and Kapoor (2006) Kale <i>et al.</i> (2007) Sakthi <i>et al.</i> (2007) Anandan (2009) Rajanna <i>et al.</i> (2011) Pujer <i>et al.</i> (2014)
10.	Micronaire value	Positive	S	Pratap <i>et al.</i> (2007) Rao and Rajamani (2009) Kumar and Ravikesavan (2010) Rajanna <i>et al.</i> (2011) Vineela (2011)
			NS	Sakthi <i>et al.</i> (2007) Pujer <i>et al.</i> (2014)
		Negative	S	Muraleedhar (2005) An <i>et al.</i> (2008) Vijayalaxmi <i>et al.</i> (2008) Mahantesh (2009) Haritha (2011) Venkatesh (2012) Anitha (2013) Rajamani <i>et al.</i> (2013)
			NS	Anandan (2009) Srinivasulu (2009) Rao <i>et al.</i> (2009a) Kumar <i>et al.</i> (2010) Venkateswarulu <i>et al.</i> (2010b) Asha <i>et al.</i> (2015)

Table 2.4 (cont.)

S. No.	Character	Association	S/NS	Reference
11.	Bundle strength	Positive	S	An <i>et al.</i> (2008) Vijayalaxmi <i>et al.</i> (2008) Kumar <i>et al.</i> (2010) Bazi (2011) Venkatesh (2012) Anitha (2013)
			NS	Srinivasulu (2009) Kumar and Ravikesavan (2010) Mahantesh <i>et al.</i> (2010) Venkateswarulu <i>et al.</i> (2010b) Vineela (2011) Asha <i>et al.</i> (2015)
		Negative	S	Raju (2005) Pujer <i>et al.</i> (2014)
			NS	Sakthi <i>et al.</i> (2007) Rao <i>et al.</i> (2009a) Rajanna <i>et al.</i> (2011) Rajamani <i>et al.</i> (2013)
12.	Uniformity ratio	Positive	S	Neelima <i>et al.</i> (2005) Pujer <i>et al.</i> (2014)
			NS	Rao <i>et al.</i> (2009a) Rajanna <i>et al.</i> (2011) Vineela (2011) Anitha (2013) Rajamani <i>et al.</i> (2013) Asha <i>et al.</i> (2015)
		Negative	S	Venkateswarulu <i>et al.</i> (2010b)
			NS	Raju (2005) Sakthi <i>et al.</i> (2007) Vijayalaxmi <i>et al.</i> (2008) Mahantesh <i>et al.</i> (2010)
13.	Lint yield per plant	Positive	S	Mahantesh (2009) Vineela (2011) Reddy <i>et al.</i> (2015)
		Negative	S	Pratap <i>et al.</i> (2007) Rao (2008) Mahantesh <i>et al.</i> (2010) Venkatesh (2012) Anitha (2013)
			NS	Vijayalaxmi <i>et al.</i> (2008) Rajanna <i>et al.</i> (2011)

Table 2.4 (cont.)

S. No.	Character	Association	S/NS	Reference
II. Plant height with				
1.	Number of monopodia per plant	Positive	S	Rauf <i>et al.</i> (2004) Kaushik and Kapoor (2006) Padmavathi (2008) Batool <i>et al.</i> (2010) Vineela (2011) Tulasi <i>et al.</i> (2012) Alkuddsi <i>et al.</i> (2013) Anitha (2013) Asha <i>et al.</i> (2015)
			NS	Rao (2008) Rajanna (2010) Rajamani <i>et al.</i> (2013) Pujer <i>et al.</i> (2014)
		Negative	NS	Pradeep and Sumalini (2005) Kale <i>et al.</i> (2007) Vijayalaxmi <i>et al.</i> (2008)
2.	Number of sympodia per plant	Positive	S	Muthu <i>et al.</i> (2004) Kaushik and Kapoor (2006) Tuteja <i>et al.</i> (2006) Verma <i>et al.</i> (2006) Pratap <i>et al.</i> (2007) Sakthi <i>et al.</i> (2007)
				An <i>et al.</i> (2008) Vijayalaxmi <i>et al.</i> (2008) Kumar and Ravikesavan (2010) Venkateswarulu <i>et al.</i> (2010b) Rajanna <i>et al.</i> (2011) Vineela (2011) Wang <i>et al.</i> (2012) Alkuddsi <i>et al.</i> (2013) Anitha (2013) Rajamani <i>et al.</i> (2013) Asha <i>et al.</i> (2015)
			NS	Pradeep and Sumalini (2005) Kale <i>et al.</i> (2007) Rao (2008) Pujer <i>et al.</i> (2014)
3.	Number of bolls per plant	Positive	S	Muthu <i>et al.</i> (2004) Kaushik and Kapoor (2006) Tuteja <i>et al.</i> (2006) Padmavathi (2008) Batool <i>et al.</i> (2010)

Table 2.6 (cont.)

S. No.	Character	Association	S/NS	Reference
3.	Number of bolls per plant	Positive	S	Venkateswarulu <i>et al.</i> (2010b) Rajanna <i>et al.</i> (2011) Vineela (2011) Tulasi <i>et al.</i> (2012) Wang <i>et al.</i> (2012) Alkuddsi <i>et al.</i> (2013) Anitha (2013) Rajamani <i>et al.</i> (2013) Asha <i>et al.</i> (2015)
				Annapurve <i>et al.</i> (2007) Anandan (2009) Rao <i>et al.</i> (2009a) Srinivasulu (2009) Khadijah <i>et al.</i> (2010) Pujer <i>et al.</i> (2014)
		Negative	S	Rauf <i>et al.</i> (2004) Haritha (2011)
			NS	Sakthi <i>et al.</i> (2007)
4.	Boll weight	Positive	S	Rauf <i>et al.</i> (2004) Karademir <i>et al.</i> (2009) Rao <i>et al.</i> (2009a) Batool <i>et al.</i> (2010) Venkateswarulu <i>et al.</i> (2010b) Vineela (2011) Tulasi <i>et al.</i> (2012) Venkatesh (2012) Rajamani <i>et al.</i> (2013) Pujer <i>et al.</i> (2014) Reddy <i>et al.</i> (2015)
			NS	Pradeep and Sumalini (2005) Annapurve <i>et al.</i> (2007) Vijayalaxmi <i>et al.</i> (2008)
		Negative	S	Anitha (2013)
			NS	Sakthi <i>et al.</i> (2007) Anandan (2009) Srinivasulu (2009) Mahantesh <i>et al.</i> (2010) Rajanna <i>et al.</i> (2011)
5.	Seed index	Positive	S	Muthu <i>et al.</i> (2004) An <i>et al.</i> (2008) Padmavathi (2008) Rao <i>et al.</i> (2009a) Batool <i>et al.</i> (2010) Mahantesh <i>et al.</i> (2010) Rajanna <i>et al.</i> (2011)

Table 2.4 (cont.)

S. No.	Character	Association	S/NS	Reference
5.	Seed index	Positive	S	Vineela (2011) Tulasi <i>et al.</i> (2012) Pujer <i>et al.</i> (2014)
			NS	Kaushik and Kapoor (2006) Kale <i>et al.</i> (2007) Sakthi <i>et al.</i> (2007) Vijayalaxmi <i>et al.</i> (2008) Anandan (2009) Venkateswarulu <i>et al.</i> (2010b) Anitha (2013)
		Negative	S	Pratap <i>et al.</i> (2007) Venkatesh (2012) Alkuddsi <i>et al.</i> (2013)
			NS	Srinivasulu (2009) Rajamani <i>et al.</i> (2013) Reddy <i>et al.</i> (2015)
6.	Lint index	Positive	S	Rao <i>et al.</i> (2009a) Batoool <i>et al.</i> (2010) Kumar and Ravikesavan (2010) Mahantesh <i>et al.</i> (2010) Rajanna <i>et al.</i> (2011) Saravanan and Koodalingam (2011) Tulasi <i>et al.</i> (2012) Pujer <i>et al.</i> (2014)
			NS	Vijayalaxmi <i>et al.</i> (2008) Anandan (2009) Venkateswarulu <i>et al.</i> (2010b) Vineela (2011) Reddy <i>et al.</i> (2015)
		Negative	S	Venkatesh (2012) Alkuddsi <i>et al.</i> (2013)
			NS	Kaushik and Kapoor (2006) Sakthi <i>et al.</i> (2007) Srinivasulu (2009) Anitha (2013) Rajamani <i>et al.</i> (2013)
7.	Ginning outturn	Positive	S	Batoool <i>et al.</i> (2010) Kumar and Ravikesavan (2010) Tulasi <i>et al.</i> (2012)
			NS	Kale <i>et al.</i> (2007) Vijayalaxmi <i>et al.</i> (2008) Rajanna <i>et al.</i> (2011) Pujer <i>et al.</i> (2014) Reddy <i>et al.</i> (2015)
		Negative	S	Pratap <i>et al.</i> (2007) Wang <i>et al.</i> (2012) Alkuddsi <i>et al.</i> (2013) Anitha (2013)

Table 2.4 (cont.)

S. No.	Character	Association	S/NS	Reference
7.	Ginning outturn	Negative	NS	Kaushik and Kapoor (2006) Annapurve <i>et al.</i> (2007) Sakthi <i>et al.</i> (2007) Rao <i>et al.</i> (2009a) Srinivasulu (2009) Venkateswarulu <i>et al.</i> (2010b) Vineela (2011) Rajamani <i>et al.</i> (2013)
8.	2.5% span length	Positive	S	Muthu <i>et al.</i> (2004) Verma <i>et al.</i> (2006) An <i>et al.</i> (2008) Kumar and Ravikesavan (2010) Thiyagu <i>et al.</i> (2010) Saravanan and Koodalingam (2011) Venkatesh (2012)
			NS	Kale <i>et al.</i> (2007) Vijayalaxmi <i>et al.</i> (2008) Rasheed <i>et al.</i> (2009) Rajanna <i>et al.</i> (2011) Vineela (2011) Anitha (2013)
		Negative	S	An <i>et al.</i> (2008) Rajamani <i>et al.</i> (2013) Reddy <i>et al.</i> (2015)
			NS	Kaushik and Kapoor (2006) Srinivasulu (2009) Rao <i>et al.</i> (2009a) Mahantesh <i>et al.</i> (2010) Venkateswarulu <i>et al.</i> (2010b)
9.	Micronaire value	Positive	S	Padmavathi (2008) Vijayalaxmi (2008) Rao <i>et al.</i> (2009a) Srinivasulu <i>et al.</i> (2010b) Thiyagu <i>et al.</i> (2010)
			NS	Vijayalaxmi <i>et al.</i> (2008) Rasheed <i>et al.</i> (2009) Venkateswarulu <i>et al.</i> (2010b) Vineela (2011) Anitha (2013) Rajamani <i>et al.</i> (2013)
		Negative	S	An <i>et al.</i> (2008) Rajanna <i>et al.</i> (2011) Venkatesh (2012)
			NS	Sakthi <i>et al.</i> (2007) Srinivasulu (2009) Mahantesh <i>et al.</i> (2010) Pujer <i>et al.</i> (2014)

Table 2.4 (cont.)

S. No.	Character	Association	S/NS	Reference		
10.	Bundle strength	Positive	S	An <i>et al.</i> (2008) Vijayalaxmi <i>et al.</i> (2008) Rasheed <i>et al.</i> (2009) Kumar and Ravikesavan (2010) Venkateswarulu <i>et al.</i> (2010b) Haritha (2011) Venkatesh (2012) Asha <i>et al.</i> (2015)		
			NS	Rao (2008) Srinivasulu (2009) Mahantesh <i>et al.</i> (2010) Rajanna <i>et al.</i> (2011) Anitha (2013)		
		Negative	S	An <i>et al.</i> (2008) Vineela (2011)		
			NS	Sakthi <i>et al.</i> (2007) Vijayalaxmi <i>et al.</i> (2008) Rajamani <i>et al.</i> (2013)		
		11.	Uniformity ratio	Positive	S	Rao (2008) Padmavathi (2008) Vijayalaxmi (2008) Srinivasulu <i>et al.</i> (2010b) Anitha (2013) Rajamani <i>et al.</i> (2013) Reddy <i>et al.</i> (2015)
					NS	Rao (2008)
Negative	S			Sakthi <i>et al.</i> (2007) Venkateswarulu <i>et al.</i> (2010b) Rajanna <i>et al.</i> (2011) Vineela (2011)		
	NS			Mahantesh <i>et al.</i> (2010) Rajanna (2010)		
12.	Lint yield per plant	Positive	S	Rajanna <i>et al.</i> (2011) Vineela (2011)		
			NS	Reddy <i>et al.</i> (2015)		
		Negative	S	Pratap <i>et al.</i> (2007)		
			NS	Rao (2008) Vijayalaxmi (2008) Anitha (2013)		
III. Number of monopodia per plant with						
1.	Number of sympodia per plant	Positive	S	Pratap <i>et al.</i> (2007) Mohan (2011) Rajanna <i>et al.</i> (2011) Venkatesh (2012) Anitha (2013) Asha <i>et al.</i> (2015)		
		Negative	S	Verma <i>et al.</i> (2006) Vijayalaxmi <i>et al.</i> (2008)		

Table 2.4 (cont.)

S. No.	Character	Association	S/NS	Reference
1.	Number of sympodia per plant	Negative	NS	Pradeep and Sumalini (2005) Vineela (2011) Alkuddsi <i>et al.</i> (2013) Rajamani <i>et al.</i> (2013)
2.	Number of bolls per plant	Positive	S	Iqbal <i>et al.</i> (2006) Verma <i>et al.</i> (2006) Pratap <i>et al.</i> (2007) Vijayalaxmi <i>et al.</i> (2008) Mohan (2011) Kishore <i>et al.</i> (2011)
			NS	Annapurve <i>et al.</i> (2007) Kale <i>et al.</i> (2007) Rajanna <i>et al.</i> (2011) Anitha (2013) Rajamani <i>et al.</i> (2013)
		Negative	S	Rauf <i>et al.</i> (2004) Vineela (2011) Pujer <i>et al.</i> (2014)
			NS	Alkuddsi <i>et al.</i> (2013)
3.	Boll weight	Positive	S	Rauf <i>et al.</i> (2004) Pratap <i>et al.</i> (2007) Shazia <i>et al.</i> (2010) Vineela (2011) Tulasi <i>et al.</i> (2012) Alkuddsi <i>et al.</i> (2013) Reddy <i>et al.</i> (2015)
			NS	Anitha (2013) Rajamani <i>et al.</i> (2013)
		Negative	S	Pratap <i>et al.</i> (2007)
			NS	Annapurve <i>et al.</i> (2007) Rao (2008) Vijayalaxmi <i>et al.</i> (2008) Rajanna <i>et al.</i> (2011)
4.	Ginning outturn	Positive	S	Annapurve <i>et al.</i> (2007) Pratap <i>et al.</i> (2007) Vijayalaxmi <i>et al.</i> (2008) Shazia <i>et al.</i> (2010) Rajanna <i>et al.</i> (2011) Tulasi <i>et al.</i> (2012)
			NS	Kale <i>et al.</i> (2007) Rao (2008) Vineela (2011) Alkuddsi <i>et al.</i> (2013)

Table 2.4 (cont.)

S. No.	Character	Association	S/NS	Reference
4.	Ginning outturn	Negative	S	Mohan (2011) Anitha (2013)
			NS	Asha <i>et al.</i> (2015)
5.	Seed index	Positive	S	Pratap <i>et al.</i> (2007) Mahantesh (2009) Shazia <i>et al.</i> (2010) Mohan (2011) Vineela (2011) Tulasi <i>et al.</i> (2012) Reddy <i>et al.</i> (2015)
			NS	Rajanna <i>et al.</i> (2011) Alkuddsi <i>et al.</i> (2013)
		Negative	S	Vijayalaxmi <i>et al.</i> (2008)
			NS	Kale <i>et al.</i> (2007) Anitha (2013) Rajamani <i>et al.</i> (2013)
6.	Lint index	Positive	S	Mahantesh (2009) Shazia <i>et al.</i> (2010) Rajanna <i>et al.</i> (2011) Vineela (2011) Tulasi <i>et al.</i> (2012) Venkatesh (2012)
			NS	Rajamani <i>et al.</i> (2013)
		Negative	S	Anitha (2013) Asha <i>et al.</i> (2015)
			NS	Raju (2005) Kale <i>et al.</i> (2007) Vijayalaxmi <i>et al.</i> (2008) Alkuddsi <i>et al.</i> (2013)
7.	2.5% span length	Positive	S	Mohan (2011) Vineela (2011) Anitha (2013) Pujer <i>et al.</i> (2014) Reddy <i>et al.</i> (2015)
			NS	Kale <i>et al.</i> (2007)
		Negative	S	Rao (2008) Rao and Rajamani (2009) Rajamani <i>et al.</i> (2013)
			NS	Verma <i>et al.</i> (2006) Vijayalaxmi <i>et al.</i> (2008) Rajanna <i>et al.</i> (2011)
8.	Micronaire value	Positive	S	Rao and Rajamani (2009) Rajamani <i>et al.</i> (2013)
			NS	Rao (2008) Rajanna <i>et al.</i> (2011) Vineela (2011)

Table 2.4 (cont.)

S. No.	Character	Association	S/NS	Reference
8.	Micronaire value	Negative	S	Muraleedhar (2005) Vijayalaxmi <i>et al.</i> (2008) Mahantesh (2009) Reddy <i>et al.</i> (2015)
			NS	Anitha (2013)
9.	Bundle strength	Positive	S	Muraleedhar (2005) Mohan (2011) Vineela (2011) Anitha (2013) Asha <i>et al.</i> (2015)
			NS	Vijayalaxmi <i>et al.</i> (2008)
		Negative	NS	Rajanna <i>et al.</i> (2011) Rajamani <i>et al.</i> (2013)
10.	Uniformity ratio	Positive	S	Rao and Rajamani (2009) Anitha (2013) Rajamani <i>et al.</i> (2013) Pujer <i>et al.</i> (2014)
			NS	Rajanna <i>et al.</i> (2011)
		Negative	S	Vijayalaxmi <i>et al.</i> (2008) Mahantesh (2009) Venkatesh (2012)
			NS	Vineela (2011)
11.	Lint yield per plant	Positive	S	Mahantesh (2009) Vineela (2011) Reddy <i>et al.</i> (2015)
			NS	Rajanna <i>et al.</i> (2011)
		Negative	NS	Anitha (2013)
IV. Number of sympodia per plant with				
1.	Number of bolls per plant	Positive	S	Muthuswamy and Vivekanandan (2004) Neelima <i>et al.</i> (2005) Tuteja <i>et al.</i> (2006) Sakthi <i>et al.</i> (2007) Mahantesh (2009) Rao and Rajamani (2009) Kumar and Ravikesavan (2010) Shazia <i>et al.</i> (2010) Venkateswarulu <i>et al.</i> (2010b) Mohan (2011) Rajanna <i>et al.</i> (2011) Vineela (2011) Wang <i>et al.</i> (2012) Anitha (2013) Rajamani <i>et al.</i> (2013) Asha <i>et al.</i> (2015)
			NS	Pradeep and Sumalini (2005) Annapurve <i>et al.</i> (2007) Kale <i>et al.</i> (2007) Alishah <i>et al.</i> (2008) Anandan (2009) Alkuddsi <i>et al.</i> (2013)

Table 2.4 (cont.)

S. No.	Character	Association	S/NS	Reference
1.	Number of bolls per plant	Negative	NS	Raju (2005) Vijayalaxmi <i>et al.</i> (2008)
2.	Boll weight	Positive	S	Neelima <i>et al.</i> (2005) Pratap <i>et al.</i> (2007) Sakthi <i>et al.</i> (2007) Kumar and Ravikesavan (2010) Shazia <i>et al.</i> (2010) Mohan (2011) Tulasi <i>et al.</i> (2012)
			NS	Rao (2008) Vijayalaxmi <i>et al.</i> (2008) Srinivasulu (2009) Venkateswarulu <i>et al.</i> (2010b) Vineela (2011) Anitha (2013) Rajamani <i>et al.</i> (2013) Asha <i>et al.</i> (2015)
		Negative	S	Pratap <i>et al.</i> (2007) Mahantesh (2009) Rao and Rajamani (2009) Rajanna <i>et al.</i> (2011) Wang <i>et al.</i> (2012) Alkuddsi <i>et al.</i> (2013)
			NS	Pradeep and Sumalini (2005) Annapurve <i>et al.</i> (2007) Kale <i>et al.</i> (2007) Anandan (2009)
3.	Ginning outturn	Positive	S	Muthu <i>et al.</i> (2004) Annapurve <i>et al.</i> (2007) Kale <i>et al.</i> (2007) Pratap <i>et al.</i> (2007) Shazia <i>et al.</i> (2007) An <i>et al.</i> (2008) Kumar and Ravikesavan (2010) Mohan (2011) Tulasi <i>et al.</i> (2012) Venkatesh (2012) Wang <i>et al.</i> (2012)
			NS	Neelima <i>et al.</i> (2005) Sakthi <i>et al.</i> (2007) Rao (2008) Rasheed <i>et al.</i> (2009) Vineela (2011)

Table 2.4 (cont.)

S. No.	Character	Association	S/NS	Reference
3.	Ginning outturn	Negative	S	Mahantesh (2009) Anitha (2013)
			NS	Vijayalaxmi <i>et al.</i> (2008) Srinivasulu (2009) Venkateswarulu <i>et al.</i> (2010b) Rajanna <i>et al.</i> (2011) Alkuddsi <i>et al.</i> (2013) Rajamani <i>et al.</i> (2013) Reddy <i>et al.</i> (2015)
4.	Seed index	Positive	S	Muthu <i>et al.</i> (2004) Neelima <i>et al.</i> (2005) Pratap <i>et al.</i> (2007) An <i>et al.</i> (2008) Mahantesh (2009) Mohan (2011) Rajanna <i>et al.</i> (2011) Tulasi <i>et al.</i> (2012) Venkatesh (2012) Anitha (2013) Reddy <i>et al.</i> (2015)
			NS	Rao (2008) Vijayalaxmi <i>et al.</i> (2008) Rasheed <i>et al.</i> (2009) Vineela (2011) Rajamani <i>et al.</i> (2013)
		Negative	S	Muthuswamy and Vivekanandan (2004) Muraleedhar (2005) Wang <i>et al.</i> (2012) Alkuddsi <i>et al.</i> (2013)
			NS	Kale <i>et al.</i> (2007) Mahantesh (2009) Venkateswarulu <i>et al.</i> (2010b)
		Positive	S	Muthu <i>et al.</i> (2004) Neelima <i>et al.</i> (2005) Pratap <i>et al.</i> (2007) Sakthi <i>et al.</i> (2007) Padmavathi (2008) Mahantesh (2009) Haritha (2011) Tulasi <i>et al.</i> (2012) Venkatesh (2012) Rajamani <i>et al.</i> (2013) Reddy <i>et al.</i> (2015)
			NS	
5.	Lint index	Positive	S	

Table 2.4 (cont.)

S. No.	Character	Association	S/NS	Reference
5.	Lint index		NS	Kale <i>et al.</i> (2007) Vijayalaxmi <i>et al.</i> (2008) Rasheed <i>et al.</i> (2009) Rajanna <i>et al.</i> (2011) Vineela (2011) Anitha (2013)
		Negative	S	Muraleedhar (2005) Venkateswarlu <i>et al.</i> (2010b)
			NS	Srinivasulu (2009) Alkuddsi <i>et al.</i> (2013)
6.	2.5% span length	Positive	S	Sakthi <i>et al.</i> (2007) Kumar and Ravikesavan (2010) Thiyagu <i>et al.</i> (2010) Mohan (2011) Anitha (2013) Reddy <i>et al.</i> (2015)
			NS	Verma <i>et al.</i> (2006) Rasheed <i>et al.</i> (2009)
		Negative	S	Raju (2005) Kale <i>et al.</i> (2007) Rao (2008) An <i>et al.</i> (2008) Vijayalaxmi <i>et al.</i> (2008) Rao and Rajamani (2009) Vineela (2011) Rajamani <i>et al.</i> (2013)
			NS	Muraleedhar (2005) Venkateswarlu <i>et al.</i> (2010b) Rajanna <i>et al.</i> (2011)
7.	Micronaire value	Positive	S	Raju (2005) An <i>et al.</i> (2008) Vijayalaxmi <i>et al.</i> (2008) Thiyagu <i>et al.</i> (2010) Mohan (2011) Asha <i>et al.</i> (2015)
			NS	Sakthi <i>et al.</i> (2007) Rasheed <i>et al.</i> (2009) Venkateswarlu <i>et al.</i> (2010b) Anitha (2013) Rajamani <i>et al.</i> (2013)
		Negative	S	Mahantesh (2009) Srinivasulu (2009) Vineela (2011)
			NS	Rao and Rajamani (2009) Rajanna <i>et al.</i> (2011)

Table 2.4 (cont.)

S. No.	Character	Association	S/NS	Reference
8.	Bundle strength	Positive	S	Muthu <i>et al.</i> (2004) Rasheed <i>et al.</i> (2009) Kumar and Ravikesavan (2010) Haritha (2011) Mohan (2011) Rajanna <i>et al.</i> (2011) Anitha (2013) Reddy <i>et al.</i> (2015)
			NS	Sakthi <i>et al.</i> (2007) Rao (2008)
		Negative	S	An <i>et al.</i> (2008) Mahantesh (2009) Rao and Rajamani (2009) Venkateswarlu <i>et al.</i> (2010b) Vineela (2011) Rajamani <i>et al.</i> (2013)
			NS	Raju (2005) Vijayalaxmi <i>et al.</i> (2008)
9.	Uniformity ratio	Positive	S	Raju (2005) Vijayalaxmi <i>et al.</i> (2008) Rao <i>et al.</i> (2009a) Rao and Rajamani (2009) Mohan (2011) Venkatesh (2012)
			NS	Rajanna <i>et al.</i> (2011) Anitha (2013) Rajamani <i>et al.</i> (2013)
		Negative	S	Venkateswarlu <i>et al.</i> (2010b)
			NS	Rao (2008) Mahantesh (2009) Vineela (2011)
10.	Lint yield per plant	Positive	S	Pratap <i>et al.</i> (2007) Rao (2008) Mahantesh (2009) Venkateswarulu <i>et al.</i> (2010b) Vineela (2011)
			NS	Vijayalaxmi <i>et al.</i> (2008) Anitha (2013)
V. Number of bolls per plant with				
1.	Boll weight	Positive	S	Neelima <i>et al.</i> (2005) Sakthi <i>et al.</i> (2007) An <i>et al.</i> (2008) Rasheed <i>et al.</i> (2009) Basamma <i>et al.</i> (2010) Kumar and Ravikesavan (2010) Shazia <i>et al.</i> (2010) Venkatesh (2012) Wang <i>et al.</i> (2012)

Table 2.6 (cont.)

S. No.	Character	Association	S/NS	Reference
1.	Boll weight	Positive		Anitha (2013) Rajamani <i>et al.</i> (2013) Pujer <i>et al.</i> (2014)
			NS	Rao (2008) Venkateswarulu <i>et al.</i> (2010b)
		Negative	S	Raju (2005) Iqbal <i>et al.</i> (2006) Vijayalaxmi <i>et al.</i> (2008) Anandan (2009) Rao and Rajamani (2009) Venkateswarulu <i>et al.</i> (2010b) Vineela (2011) Alkuddsi <i>et al.</i> (2013)
			NS	Iqbal <i>et al.</i> (2006) Annapurve <i>et al.</i> (2007) Kale <i>et al.</i> (2007) Srinivasulu (2009) Rao and Gopinath (2013)
2.	Seed index	Positive	S	Muthu <i>et al.</i> (2004) Neelima <i>et al.</i> (2005) Mahantesh (2009) Kumar and Ravikesavan (2010)
			NS	Srinivasulu (2009)
		Negative	S	Muraleedhar (2005) Vijayalaxmi <i>et al.</i> (2008) Mohan (2011) Venkatesh (2012) Wang <i>et al.</i> (2012)
			NS	Kale <i>et al.</i> (2007) Rao (2008) Venkateswarulu <i>et al.</i> (2010b) Vineela (2011) Alkuddsi <i>et al.</i> (2013) Anitha (2013) Rajamani <i>et al.</i> (2013)
3.	Lint index	Positive	S	Muthu <i>et al.</i> (2004) Neelima <i>et al.</i> (2005) Anandan (2009) Kumar and Ravikesavan (2010)
			NS	Sakthi <i>et al.</i> (2007) Mahantesh (2009) Srinivasulu (2009) Vineela (2011) Anitha (2013) Rajamani <i>et al.</i> (2013) Reddy <i>et al.</i> (2015)

Table 2.4 (cont.)

S. No.	Character	Association	S/NS	Reference
3.	Lint index	Negative	S	Raju (2005) Vijayalaxmi <i>et al.</i> (2008) Venkateswarlu <i>et al.</i> (2010b) Mohan (2011) Alkuddsi <i>et al.</i> (2013)
			NS	Rao (2008) Rajanna <i>et al.</i> (2011)
4.	Ginning outturn	Positive	S	Muthu <i>et al.</i> (2004) Pratap <i>et al.</i> (2007) Anandan (2009) Kumar and Ravikesavan (2010) Mahantesh <i>et al.</i> (2010) Shazia <i>et al.</i> (2010) Vineela (2011) Venkatesh (2012)
			NS	Annapurve <i>et al.</i> (2007) Sakthi <i>et al.</i> (2007) Rao (2008) Vijayalaxmi <i>et al.</i> (2008) Srinivasulu (2009) Rajamani <i>et al.</i> (2013) Rao and Gopinath (2013) Pujer <i>et al.</i> (2014)
		Negative	S	Raju (2005) Venkateswarlu <i>et al.</i> (2010b) Haritha (2011) Mohan (2011)
			NS	Rajanna <i>et al.</i> (2011) Alkuddsi <i>et al.</i> (2013) Anitha (2013)
5.	2.5% span length	Positive	S	An <i>et al.</i> (2008) Kumar and Ravikesavan (2008) Thiyagu <i>et al.</i> (2010) Mohan (2011)
			NS	Sakthi <i>et al.</i> (2007) Rao (2008) Mahantesh (2009) Kumar and Ravikesavan (2010) Rao and Gopinath (2013) Reddy <i>et al.</i> (2015)
		Negative	S	Muraleedhar (2005) Vineela (2011) Anitha (2013) Rajamani <i>et al.</i> (2013)
			NS	Vijayalaxmi <i>et al.</i> (2008) Anandan (2009) Venkateswarlu <i>et al.</i> (2010b) Rajanna <i>et al.</i> (2011)

Table 2.4 (cont.)

S. No.	Character	Association	S/NS	Reference
6.	Micronaire value	Positive	S	Muthu <i>et al.</i> (2004) Raju (2005) Sakthi <i>et al.</i> (2007) Rao (2008) Anandan (2009) Kumar and Ravikesavan (2010) Thiyagu <i>et al.</i> (2010) Venkateswarlu <i>et al.</i> (2010b) Venkatesh (2012) Anitha (2013) Asha <i>et al.</i> (2015)
			NS	Rao and Gopinath (2013)
		Negative	S	Pratap <i>et al.</i> (2007) An <i>et al.</i> (2008) Vijayalaxmi <i>et al.</i> (2008) Mohan (2011) Vineela (2011)
			NS	Mahantesh (2009) Rajanna <i>et al.</i> (2011) Rajamani <i>et al.</i> (2013)
7.	Bundle strength	Positive	S	Muthu <i>et al.</i> (2004) An <i>et al.</i> (2008) Kumar and Ravikesavan (2010) Haritha (2011) Venkatesh (2012)
			NS	Sakthi <i>et al.</i> (2007) Vijayalaxmi <i>et al.</i> (2008) Rajanna <i>et al.</i> (2011) Rajamani <i>et al.</i> (2013) Rao and Gopinath (2013) Pujer <i>et al.</i> (2014)
		Negative	S	Rao and Rajamani (2009) Vineela (2011) Anitha (2013)
			NS	Raju (2005) Rao (2008) Anandan (2009) Venkateswarlu <i>et al.</i> (2010b)
8.	Uniformity ratio	Positive	S	Muthu <i>et al.</i> (2004) Haritha (2011) Venkatesh (2012)
			NS	Srinivasulu (2009) Rajanna <i>et al.</i> (2011) Vineela (2011) Rajamani <i>et al.</i> (2013)

Table 2.4 (cont.)

S. No.	Character	Association	S/NS	Reference
8.	Uniformity ratio	Negative	S	Vijayalaxmi <i>et al.</i> (2008) Mohan (2011) Anitha (2013)
			NS	Sakthi <i>et al.</i> (2007) Anandan (2009) Venkateswarlu <i>et al.</i> (2010b) Rao and Gopinath (2013) Asha <i>et al.</i> (2015)
9.	Lint yield per plant	Positive	S	Pratap <i>et al.</i> (2007) Rao (2008) Vijayalaxmi <i>et al.</i> (2008) Mahantesh <i>et al.</i> (2010) Venkateswarlu <i>et al.</i> (2010b) Rajanna <i>et al.</i> (2011) Vineela (2011) Venkatesh (2012) Anitha (2013) Rao and Gopinath (2013) Reddy <i>et al.</i> (2015)
VI. Boll weight with				
1.	Seed index	Positive	S	Muthu <i>et al.</i> (2004) An <i>et al.</i> (2008) Padmavathi (2008) Kumar and Ravikesavan (2010) Venkateswarlu <i>et al.</i> (2010b) Mohan (2011) Rajanna <i>et al.</i> (2011) Vineela (2011) Wang <i>et al.</i> (2012) Rajamani <i>et al.</i> (2013)
			NS	Anandan (2009) Alkuddsi <i>et al.</i> (2013) Reddy <i>et al.</i> (2015)
		Negative	S	Rao (2008) Anitha (2013)
			NS	Mahantesh (2009) Srinivasulu (2009)
2.	Lint index	Positive	S	Muthuswamy and Vivekanandan (2004) Neelima <i>et al.</i> (2005) Sakthi <i>et al.</i> (2007) An <i>et al.</i> (2008) Rao (2008) Vijayalaxmi <i>et al.</i> (2008) Kumar and Ravikesavan (2010) Venkateswarlu <i>et al.</i> (2010b) Haritha (2011) Mohan (2011) Rajanna <i>et al.</i> (2011)

Table 2.4 (cont.)

S. No.	Character	Association	S/NS	Reference
2.	Lint index	Positive		Vineela (2011) Rajamani <i>et al.</i> (2013)
			NS	Rao <i>et al.</i> (2009a) Alkuddsi <i>et al.</i> (2013)
		Negative	NS	Anandan (2009) Srinivasulu (2009) Anitha (2013)
3.	Ginning outturn	Positive	S	Muthuswamy and Vivekanandan (2004) Raju (2005) Rasheed <i>et al.</i> (2009) Kumar and Ravikesavan (2010) Mohan (2011) Venkatesh (2012) Alkuddsi <i>et al.</i> (2013) Anitha (2013) Pujer <i>et al.</i> (2014)
			NS	Srinivasulu (2009) Venkateswarlu <i>et al.</i> (2010b) Rajanna <i>et al.</i> (2011) Rajamani <i>et al.</i> (2013)
		Negative	S	Rao and Gopinath (2013)
			NS	Sakthi <i>et al.</i> (2007) Vijayalaxmi <i>et al.</i> (2008) Anandan (2009) Mahantesh (2009) Vineela (2011)
4.	2.5% span length	Positive	S	Verma <i>et al.</i> (2006) Vijayalaxmi <i>et al.</i> (2008) An <i>et al.</i> (2008) Rao and Rajamani (2009) Kumar and Ravikesavan (2010) Vineela (2011) Venkatesh (2012) Reddy <i>et al.</i> (2015)
			NS	Kale <i>et al.</i> (2007) Sakthi <i>et al.</i> (2007) Anandan (2009) Srinivasulu (2009) Rajanna <i>et al.</i> (2011) Rajamani <i>et al.</i> (2013) Rao and Gopinath (2013)
		Negative	S	Mohan (2011) Anitha (2013)
			NS	Rao (2008) Venkateswarulu <i>et al.</i> (2010b)

Table 2.4 (cont.)

S. No.	Character	Association	S/NS	Reference
5.	Micronaire value	Positive	S	Rao and Rajamani (2009) Venkateswarulu <i>et al.</i> (2010b) Vineela (2011) Anitha (2013) Rao and Gopinath (2013)
			NS	Sakthi <i>et al.</i> (2007) Rao (2008) Rajamani <i>et al.</i> (2013)
		Negative	S	Venkatesh (2012)
			NS	Vijayalaxmi <i>et al.</i> (2008) Srinivasulu (2009) Mahantesh <i>et al.</i> (2010) Asha <i>et al.</i> (2015)
6.	Bundle strength	Positive	S	Muraleedhar (2005) Rao (2008) Rao and Rajamani (2009) Kumar and Ravikesavan (2010) Vineela (2011) Venkatesh (2012) Rajamani <i>et al.</i> (2013) Reddy <i>et al.</i> (2015)
			NS	Muthuswamy and Vivekanandan (2004) Sakthi <i>et al.</i> (2007) Vijayalaxmi <i>et al.</i> (2008) Anandan (2009)
		Negative	S	Haritha (2011) Mohan (2011) Anitha (2013)
			NS	Srinivasulu (2009) Rajanna <i>et al.</i> (2011) Rao and Gopinath (2013)
7.	Uniformity ratio	Positive	S	Rao (2008) Venkateswarulu <i>et al.</i> (2010b)
			NS	Rajanna <i>et al.</i> (2011) Rao and Gopinath (2013)
		Negative	S	Rao (2008) Rao and Rajamani (2009) Anitha (2013) Pujer <i>et al.</i> (2014)
			NS	Sakthi <i>et al.</i> (2007) Vijayalaxmi <i>et al.</i> (2008) Mahantesh (2009) Vineela (2011)
8.	Lint yield per plant	Positive	S	Rao (2008) Rajanna <i>et al.</i> (2011) Venkatesh (2012) Anitha (2013) Rao and Gopinath (2013) Reddy <i>et al.</i> (2015)

Table 2.4 (cont.)

S. No.	Character	Association	S/NS	Reference
VII. Seed index with				
1.	Lint index	Positive	S	Neelima <i>et al.</i> (2005) Raju (2005) An <i>et al.</i> (2008) Mahantesh (2009) Venkateswarlu <i>et al.</i> (2010b) Rajanna <i>et al.</i> (2011) Vineela (2011) Venkatesh (2012) Alkuddsi <i>et al.</i> (2013) Anitha (2013) Rajamani <i>et al.</i> (2013) Pujer <i>et al.</i> (2014) Reddy <i>et al.</i> (2015)
			NS	Anandan (2009) Haritha (2011)
2.	Ginning outturn	Positive	S	Rajamani <i>et al.</i> (2013)
			NS	Kale <i>et al.</i> (2007)
		Negative	S	Mohan (2011) Rajanna <i>et al.</i> (2011) Anitha (2013) Reddy <i>et al.</i> (2015)
3.	2.5% span length	Positive	S	An <i>et al.</i> (2008) Padmavathi (2008) Vijayalaxmi <i>et al.</i> (2008) Haritha (2011) Mohan (2011) Rajanna <i>et al.</i> (2011) Vineela (2011) Rajamani <i>et al.</i> (2013) Pujer <i>et al.</i> (2014)
			NS	Anandan (2009) Srinivasulu (2009) Venkateswarulu <i>et al.</i> (2010b) Anitha (2013)
		Negative	S	Kale <i>et al.</i> (2007)
4.	Micronaire value	Positive	S	An <i>et al.</i> (2008) Rao (2008) Vijayalaxmi <i>et al.</i> (2008) Vineela (2011) Rajamani <i>et al.</i> (2013)
			NS	Venkateswarulu <i>et al.</i> (2010b)
		Negative	S	Mahantesh (2009) Mohan (2011) Rajanna <i>et al.</i> (2011) Anitha (2013)
			NS	Anandan (2009) Venkateswarulu <i>et al.</i> (2010b) Reddy <i>et al.</i> (2015)

Table 2.4 (cont.)

S. No.	Character	Association	S/NS	Reference
5.	Bundle strength	Positive	S	Padmavathi (2008) Srinivasulu <i>et al.</i> (2010b) Mohan (2011)
			NS	Anandan (2009) Venkateswarulu <i>et al.</i> (2010b) Anitha (2013) Asha <i>et al.</i> (2015)
		Negative	S	Rajanna <i>et al.</i> (2011) Venkatesh (2012)
			NS	Vijayalaxmi <i>et al.</i> (2008) Mahantesh (2009) Vineela (2011) Rajamani <i>et al.</i> (2013)
6.	Uniformity ratio	Positive	S	Venkateswarulu <i>et al.</i> (2010b) Venkatesh (2012) Anitha (2013)
			NS	Vijayalaxmi (2008)
		Negative	S	Rajanna <i>et al.</i> (2011)
			NS	Rao (2008) Anandan (2009) Mahantesh (2009) Srinivasulu (2009) Rajamani <i>et al.</i> (2013)
7.	Lint yield per plant	Positive	S	Mahantesh (2009) Vineela (2011)
			NS	Rao (2008)
		Negative	S	Venkatesh (2012) Anitha (2013)
			NS	Vijayalaxmi <i>et al.</i> (2008) Rajanna <i>et al.</i> (2011) Reddy <i>et al.</i> (2015)
VIII. Lint index with				
1.	Ginning outturn	Positive	S	Sakthi <i>et al.</i> (2007) Pratap <i>et al.</i> (2007) Vijayalaxmi <i>et al.</i> (2008) Haritha (2011) Mohan (2011) Rajanna <i>et al.</i> (2011) Venkatesh (2012) Anitha (2013) Reddy <i>et al.</i> (2015)
			NS	Rajamani <i>et al.</i> (2013)
2.	2.5% span length	Positive	S	Muthu <i>et al.</i> (2004) Murthy <i>et al.</i> (2006) Sakthi <i>et al.</i> (2007) Vijayalaxmi <i>et al.</i> (2008) Rasheed <i>et al.</i> (2009) Kumar and Ravikesavan (2010) Asha <i>et al.</i> (2015)

Table 2.4 (cont.)

S. No.	Character	Association	S/NS	Reference
2.	2.5% span length	Positive	NS	Rao <i>et al.</i> (2009a) Rajanna <i>et al.</i> (2011) Vineela (2011) Anitha (2013)
			S	Mohan (2011)
		Negative	NS	Anandan (2009) Srinivasulu (2009) Venkteswarulu <i>et al.</i> (2010b)
3.	Micronaire value	Positive	S	An <i>et al.</i> (2008) Rao (2008) Kumar and Ravikesavan (2010) Vineela (2011)
			NS	Vijayalaxmi (2008) Anandan (2009) Venkateswarulu <i>et al.</i> (2010b) Rajanna <i>et al.</i> (2011) Rajamani <i>et al.</i> (2013) Reddy <i>et al.</i> (2015)
		Negative	S	Mahantesh (2009)
			NS	Srinivasulu (2009) Anitha (2013)
		Positive	S	Muthu <i>et al.</i> (2004) Murthy <i>et al.</i> (2006) Kumar and Ravikesavan (2010)
			NS	Sakthi <i>et al.</i> (2007) Vijayalaxmi <i>et al.</i> (2008) Anandan (2009) Venkateswarulu <i>et al.</i> (2010b) Asha <i>et al.</i> (2015)
4.	Bundle strength	Positive	S	Vineela (2011) Venkatesh (2012) Anitha (2013)
			NS	Raju (2005) Rao <i>et al.</i> (2009a) Mahantesh <i>et al.</i> (2010) Rajanna <i>et al.</i> (2011) Rajamani <i>et al.</i> (2013)
		Negative	S	Venkateswarulu <i>et al.</i> (2010b) Mohan (2011)
			NS	Vijayalaxmi <i>et al.</i> (2008) Srinivasulu (2009) Vineela (2011) Anitha (2013)
5.	Uniformity ratio	Positive	S	Sakthi <i>et al.</i> (2007) Rajanna <i>et al.</i> (2011)
			NS	Rao (2008) Mahantesh <i>et al.</i> (2010) Rajamani <i>et al.</i> (2013)
		Negative	S	
			NS	

Table 2.4 (cont.)

S. No.	Character	Association	S/NS	Reference
6.	Lint yield per plant	Positive	S	Pratap <i>et al.</i> (2007) Mahantesh (2009) Rajanna <i>et al.</i> (2011) Reddy <i>et al.</i> (2015)
			NS	Rao (2008) Vijayalaxmi <i>et al.</i> (2008)
		Negative	S	Muthu <i>et al</i> (2004)
			NS	Anitha (2013)
IX. Ginning outturn with				
1.	2.5% span length	Positive	S	Kale <i>et al.</i> (2007)
			NS	Rajamani <i>et al.</i> (2013) Asha <i>et al.</i> (2015)
		Negative	S	Muthu <i>et al.</i> (2004) Sakthi <i>et al.</i> (2007) An <i>et al.</i> (2008) Mahantesh (2009) Vineela (2011) Anitha (2013)
			NS	Kale <i>et al.</i> (2007) Vijayalaxmi <i>et al.</i> (2008) Rajanna (2010)
2.	Micronaire value	Positive	S	Muthu <i>et al.</i> (2004) An <i>et al.</i> (2008) Padmavathi (2008) Mohan (2011)
			NS	Rao (2008) Mahantesh <i>et al.</i> (2010) Venkateswarulu <i>et al.</i> (2010b) Vineela (2011) Rajamani <i>et al.</i> (2013) Reddy <i>et al.</i> (2015)
		Negative	S	Vijayalaxmi <i>et al.</i> (2008)
			NS	Raju (2005) Anandan (2009) Srinivasulu (2009)
3.	Bundle strength	Positive	S	Murthy <i>et al.</i> (2006) Rao (2008) Kumar and Ravikesavan (2010) Pujer <i>et al.</i> (2014)
			NS	Vijayalaxmi <i>et al.</i> (2008) Srinivasulu (2009)
		Negative	S	Mahantesh (2009) Mohan (2011) Vineela (2011) Anitha (2013)
			NS	Sakthi <i>et al.</i> (2007)

Table 2.4 (cont.)

S. No.	Character	Association	S/NS	Reference
3.	Bundle strength	Negative	NS	Anandan (2009) Rajanna <i>et al.</i> (2011) Rajamani <i>et al.</i> (2013) Rao and Gopinath (2013)
4.	Uniformity ratio	Positive	S	Muthu <i>et al.</i> (2004) Raju (2005) Sakthi <i>et al.</i> (2007) Padmavathi (2008) Kumar and Ravikesavan (2010) Mohan (2011) Rajamani <i>et al.</i> (2013)
			NS	Sakthi <i>et al.</i> (2007) Rajanna <i>et al.</i> (2011) Rao and Gopinath (2013)
		Negative	S	Anitha (2013)
			NS	Rao (2008) Vijayalaxmi <i>et al.</i> (2008) Anandan (2009)
5.	Lint yield per plant	Positive	S	Pratap <i>et al.</i> (2007) Rao (2008) Vijayalaxmi <i>et al.</i> (2008) Rajanna <i>et al.</i> (2011) Vineela (2011) Venkatesh (2012) Anitha (2013) Rao and Gopinath (2013) Reddy <i>et al.</i> (2015)
X. 2.5% span length with				
1.	Micronaire value	Positive	S	Muthuswamy and Vivekanandan (2004) Rao and Gopinath (2013)
			NS	Anandan (2009) Srinivasulu (2009)
		Negative	S	Pratap <i>et al.</i> (2007) Padmavathi (2008) Vijayalaxmi <i>et al.</i> (2008) Venkateswarlu <i>et al.</i> (2010b) Haritha (2011) Mohan (2011) Rajanna <i>et al.</i> (2011) Anitha (2013) Rajamani <i>et al.</i> (2013) Reddy <i>et al.</i> (2015)
			NS	Sakthi <i>et al.</i> (2007) Rao (2008) Mahantesh <i>et al.</i> (2010)

Table 2.4 (cont.)

S. No.	Character	Association	S/NS	Reference
2.	Bundle strength	Positive	S	Muthuswamy and Vivekanandan (2004) Rathore <i>et al.</i> (2004) Raju (2005) Tuteja <i>et al.</i> (2006) An <i>et al.</i> (2008) Kumar and Ravikesavan (2010) Mahantesh <i>et al.</i> (2010) Venkateswarlu <i>et al.</i> (2010b) Mohan (2011) Rajanna <i>et al.</i> (2011) Vineela (2011) Venkatesh (2012) Anitha (2013) Rajamani <i>et al.</i> (2013) Rao and Gopinath (2013) Asha <i>et al.</i> (2015)
			NS	Padmavathi (2008) Vijayalaxmi <i>et al.</i> (2008) Anandan (2009)
		Negative	NS	Srinivasulu (2009)
3.	Uniformity ratio	Positive	S	Pratap <i>et al.</i> (2007) Rao (2008) Vijayalaxmi <i>et al.</i> (2008) Rajanna (2010) Venkatesh (2012) Rao and Gopinath (2013)
			S	Rao and Rajamani (2009) Venkateswarlu <i>et al.</i> (2010b) Mohan (2011) Rajanna <i>et al.</i> (2011) Vineela (2011) Rajamani <i>et al.</i> (2013) Reddy <i>et al.</i> (2015)
		Negative	NS	Muthu <i>et al.</i> (2004) Tuteja <i>et al.</i> (2006) Anandan (2009) Srinivasulu (2009) Mahantesh <i>et al.</i> (2010) Anitha (2013)
4.	Lint yield per plant	Positive	NS	Vijayalaxmi <i>et al.</i> (2008) Venkatesh (2012) Rao and Gopinath (2013)
		Negative	S	Rajanna <i>et al.</i> (2011) Vineela (2011)
			NS	Rao (2008) Anitha (2013) Reddy <i>et al.</i> (2015)

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Table 2.6 (cont.)

S. No.	Character	Association	S/NS	Reference
XI. Micronaire value with				
1.	Bundle strength	Positive	NS	Srinivasulu (2009)
		Negative	S	Raju (2005) Rao (2008) Vijayalaxmi <i>et al.</i> (2008) An <i>et al.</i> (2008) Mahantesh (2009) Rao and Rajamani (2009) Hussain <i>et al.</i> (2010) Venkateswarulu <i>et al.</i> (2010b) Vineela (2011) Venkatesh (2012) Anitha (2013) Reddy <i>et al.</i> (2015)
			NS	Tuteja <i>et al.</i> (2006) Anandan (2009) Rajanna <i>et al.</i> (2011) Rao and Gopinath (2013)
2.	Uniformity ratio	Positive	S	Raju (2005) Vijayalaxmi <i>et al.</i> (2008) Rao and Rajamani (2009) Mahantesh <i>et al.</i> (2010) Srinivasulu <i>et al.</i> (2010b) Venkateswarlu <i>et al.</i> (2010b) Rajanna <i>et al.</i> (2011) Vineela (2011) Rajamani <i>et al.</i> (2013) Rao and Gopinath (2013)
			NS	Muthu <i>et al.</i> (2004) Rao <i>et al.</i> (2009a) Srinivasulu (2009) Anitha (2013)
		Negative	S	Tuteja <i>et al.</i> (2006)
			NS	Anandan (2009) Pujer <i>et al.</i> (2014)
3.	Lint yield per plant	Positive	S	Rao (2008) Venkateswarulu <i>et al.</i> (2010b) Vineela (2011) Anitha (2013) Rao and Gopinath (2013)
		Negative	S	Rajanna <i>et al.</i> (2011)
			NS	Haritha (2011) Reddy <i>et al.</i> (2015)

Table 2.4 (cont.)

S. No.	Character	Association	S/NS	Reference
XII. Bundle strength with				
1.	Uniformity ratio	Positive	S	Venkatesh (2012)
		Negative	S	Pratap <i>et al.</i> (2007) Padmavathi (2008) Vijayalaxmi <i>et al.</i> (2008) Rao and Rajamani (2009) Venkateswarulu <i>et al.</i> (2010b) Vineela (2011) Rajamani <i>et al.</i> (2013) Rao and Gopinath (2013)
			NS	Rao <i>et al.</i> (2009a) Anitha (2013) Asha <i>et al.</i> (2015)
2.	Lint yield per plant (g)	Positive	S	Venkatesh (2012)
			NS	Reddy <i>et al.</i> (2015)
		Negative	S	Vineela (2011) Anitha (2013)
			NS	Rao (2008) Rajanna <i>et al.</i> (2011)
XIII. Uniformity ratio with				
1.	Micronaire value	Positive	S	Vijayalaxmi <i>et al.</i> (2008) Mohan (2011) Anitha (2013)
2.	Bundle strength	Positive	NS	Pratap <i>et al.</i> (2007) Vijayalaxmi <i>et al.</i> (2008)
		Negative	NS	Rajanna <i>et al.</i> (2011)
3.	Lint yield per plant	Positive	S	Venkatesh (2012)
			NS	Rajanna <i>et al.</i> (2011) Vineela (2011) Anitha (2013) Rao and Gopinath (2013) Reddy <i>et al.</i> (2015)
		Negative	NS	Vijayalaxmi <i>et al.</i> (2008)
XIV. Lint yield per plant with				
1.	Seed cotton yield per plant	Positive	S	Pratap <i>et al.</i> (2007) Rao (2008) Mahantesh (2009) Rajanna <i>et al.</i> (2011) Vineela (2011) Venkatesh (2012) Anitha (2013) Rao and Gopinath (2013) Reddy <i>et al.</i> (2015)

Note: S: Significant, NS: Non-significant

Table 2.3. Review of literature on association of component characters with seed cotton yield in cotton (*Gossypium hirsutum* L.)

S. No.	Character	Association	S/NS	Reference
1	Days to 50% flowering	Positive	S	Tuteja <i>et al.</i> (2006) Mahantesh (2009) Kumar and Ravikesavan (2010) Bazi (2011) Vineela <i>et al.</i> (2012a) Alkuddsi <i>et al.</i> (2013) Pujer <i>et al.</i> (2014)
			NS	Kaushik and Kapoor (2006) Kale <i>et al.</i> (2007) Rajamani <i>et al.</i> (2013) Reddy <i>et al.</i> (2015)
		Negative	S	Anitha (2013)
			NS	Kaushik and Kapoor (2006) Annapurve <i>et al.</i> (2007) Rao (2008) Vijayalaxmi <i>et al.</i> (2008) Venkateswarulu <i>et al.</i> (2010b) Haritha (2011) Rajanna <i>et al.</i> (2011) Asha <i>et al.</i> (2015)
2	Plant height	Positive	S	Muraleedhar (2005) Kaushik and Kapoor (2006) Rao (2008) Mahantesh (2009) Kumar and Ravikesavan (2010) Thiyagu <i>et al.</i> (2010) Tulasi <i>et al.</i> (2012) Vineela <i>et al.</i> (2012a) Wang <i>et al.</i> (2012) Alkuddsi <i>et al.</i> (2013) Erande <i>et al.</i> (2014) Pujer <i>et al.</i> (2014) Asha <i>et al.</i> (2015)
			NS	Rahman <i>et al.</i> (2013) Rajamani <i>et al.</i> (2013)
		Negative	S	Rauf <i>et al.</i> (2004) Pratap <i>et al.</i> (2007) Haritha (2011)
			NS	Raju (2005) Annapurve <i>et al.</i> (2007) Kale <i>et al.</i> (2007) Vijayalaxmi <i>et al.</i> (2008) Anitha (2013)

S. No.	Character	Association	S/NS	Reference
3	Number of monopodia per plant	Positive	S	Iqbal <i>et al.</i> (2006) Mahantesh (2009) Kumar and Ravikesavan (2010) Mohan (2011) Tulasi <i>et al.</i> (2012) Vineela <i>et al.</i> (2012a) Erande <i>et al.</i> (2014) Reddy <i>et al.</i> (2015)
			NS	Pradeep and Sumalini (2005) Kaushik and Kapoor (2006) Vijayalaxmi <i>et al.</i> (2008) Kishore <i>et al.</i> (2011) Rajanna <i>et al.</i> (2011) Alkuddsi <i>et al.</i> (2013) Rajamani <i>et al.</i> (2013)
		Negative	S	Rauf <i>et al.</i> (2004) Batool <i>et al.</i> (2010)
			NS	Raju (2005) Rao (2008) Venkateswarlu <i>et al.</i> (2010b)
4	Number of sympodia per plant	Positive	S	Rauf <i>et al.</i> (2004) Kaushik and Kapoor (2006) Annapurve <i>et al.</i> (2007) Kale <i>et al.</i> (2007) Vijayalaxmi <i>et al.</i> (2008) Mahantesh (2009) Batool <i>et al.</i> (2010) Ekinci <i>et al.</i> (2010) Kumar and Ravikesavan (2010) Thiyagu <i>et al.</i> (2010) Mohan (2011) Rajanna <i>et al.</i> (2011) Tulasi <i>et al.</i> (2012) Vineela <i>et al.</i> (2012a) Wang <i>et al.</i> (2012) Rahman <i>et al.</i> (2013) Rajamani <i>et al.</i> (2013) Erande <i>et al.</i> (2014) Asha <i>et al.</i> (2015)
			NS	Raju (2005) Rao (2008) Kishore <i>et al.</i> (2011) Alkuddsi <i>et al.</i> (2013)
		Negative	NS	Rao (2008)

Table 2.3 (contd..)

S. No.	Character	Association	S/NS	Reference
5	Number of bolls per plant	Positive	S	Rauf <i>et al.</i> (2004) Neelima <i>et al.</i> (2005) Kaushik and Kapoor (2006) Tuteja <i>et al.</i> (2006) Verma <i>et al.</i> (2006) Pratap <i>et al.</i> (2007) Rao (2008) Vijayalaxmi <i>et al.</i> (2008) Mahantesh (2009) Basamma <i>et al.</i> (2010) Ekinci <i>et al.</i> (2010) Kumar and Ravikesavan (2010) Thiyagu <i>et al.</i> (2010) Bazi (2011) Haritha (2011) Kishore <i>et al.</i> (2011) Tulasi <i>et al.</i> (2012) Vineela <i>et al.</i> (2012a) Wang <i>et al.</i> (2012) Alkuddsi <i>et al.</i> (2013) Rajamani <i>et al.</i> (2013) Rao and Gopinath (2013) Erande <i>et al.</i> (2014) Pujer <i>et al.</i> (2014) Asha <i>et al.</i> (2015)
			NS	Pradeep and Sumalani (2005) Annapurve <i>et al.</i> (2007)
6	Boll weight	Positive	S	Neelima <i>et al.</i> (2005) Raju (2005) Iqbal <i>et al.</i> (2006) Murthy <i>et al.</i> (2006) Kale <i>et al.</i> (2007) Rao (2008) Mahantesh (2009) Basamma <i>et al.</i> (2010) Batool <i>et al.</i> (2010) Ekinci <i>et al.</i> (2010) Kumar and Ravikesavan (2010) Shazia <i>et al.</i> (2010) Haritha (2011) Kishore <i>et al.</i> (2011) Tulasi <i>et al.</i> (2012) Vineela <i>et al.</i> (2012a) Alkuddsi <i>et al.</i> (2013) Rajamani <i>et al.</i> (2013) Rao and Gopinath (2013) Erande <i>et al.</i> (2014) Reddy <i>et al.</i> (2015)
			NS	Vijayalaxmi <i>et al.</i> (2008)

Table 2.3 (contd..)

S. No.	Character	Association	S/NS	Reference
7	Seed index	Positive	S	Gururajan and Sundar (2004) Muthu <i>et al.</i> (2004) Neelima <i>et al.</i> (2005) Murthy <i>et al.</i> (2006) An <i>et al.</i> (2008) Mahantesh (2009) Thiyagu <i>et al.</i> (2010) Tulasi <i>et al.</i> (2012) Vineela <i>et al.</i> (2012a) Rajamani <i>et al.</i> (2013) Pujer <i>et al.</i> (2014)
			NS	Kaushik and Kapoor (2006) Vijayalaxmi (2007) Rao (2008) Naqib <i>et al.</i> (2010) Kishore <i>et al.</i> (2011)
		Negative	S	Alkuddsi <i>et al.</i> (2013) Anitha (2013)
			NS	Raju (2005) Haritha (2011) Rajanna <i>et al.</i> (2011) Venkatesh (2012) Asha <i>et al.</i> (2015)
8	Lint index	Positive	S	Murthy <i>et al.</i> (2006) An <i>et al.</i> (2008) Kumar and Ravikesavan (2010) Naqib <i>et al.</i> (2010) Shazia <i>et al.</i> (2010) Thiyagu <i>et al.</i> (2010) Haritha (2011) Tulasi <i>et al.</i> (2012) Vineela <i>et al.</i> (2012a) Rajamani <i>et al.</i> (2013) Pujer <i>et al.</i> (2014)
			NS	Vijayalaxmi (2007) Rao (2008) Mohan (2011) Rajanna <i>et al.</i> (2011) Reddy <i>et al.</i> (2015)
		Negative	S	Venkateswarlu <i>et al.</i> (2010b) Anitha (2013)
			NS	Kaushik and Kapoor (2006) Kishore <i>et al.</i> (2011) Alkuddsi <i>et al.</i> (2013) Asha <i>et al.</i> (2015)

Table 2.3 (contd..)

S. No.	Character	Association	S/NS	Reference
9	Ginning outturn	Positive	S	Tuteja <i>et al.</i> (2006) Annapurve <i>et al.</i> (2007) Kale <i>et al.</i> (2007) Naqib <i>et al.</i> (2010) Shazia <i>et al.</i> (2010) Haritha (2011) Tulasi <i>et al.</i> (2012) Alkuddsi <i>et al.</i> (2013) Rajamani <i>et al.</i> (2013) Rao and Gopinath (2013) Pujer <i>et al.</i> (2014)
			NS	Rao (2008) Rajanna <i>et al.</i> (2011) Reddy <i>et al.</i> (2015)
		Negative	S	Muthuswamy and Vivekanandan (2004) Venkateswarlu <i>et al.</i> (2010b) Mohan (2011)
			NS	Raju (2005) Iqbal <i>et al.</i> (2006) Kaushik and Kapoor (2006) Vijayalaxmi <i>et al.</i> (2008) Kishore <i>et al.</i> (2011)
		Positive	S	Thiyagu <i>et al.</i> (2010) Asha <i>et al.</i> (2015)
			NS	Kumar <i>et al.</i> (2010) Rajamani <i>et al.</i> (2013) Rao and Gopinath (2013)
10	2.5% span length	Positive	S	Thiyagu <i>et al.</i> (2010) Asha <i>et al.</i> (2015)
			NS	Kumar <i>et al.</i> (2010) Rajamani <i>et al.</i> (2013) Rao and Gopinath (2013)
		Negative	S	Venkateswarlu <i>et al.</i> (2010b) Kishore <i>et al.</i> (2011) Mohan (2011) Venkatesh (2012) Anitha (2013) Pujer <i>et al.</i> (2014)
			NS	Kaushik and Kapoor (2006) Kale <i>et al.</i> (2007) Rao (2008) Vijayalaxmi <i>et al.</i> (2008) Rajanna <i>et al.</i> (2011)

Table 2.3 (contd..)

S. No.	Character	Association	S/NS	Reference
11	Micronaire value	Positive	S	Neelima <i>et al.</i> (2005) Raju (2005) Mahantesh (2009) Venkateswarlu <i>et al.</i> (2010b) Vineela <i>et al.</i> (2012a) Anitha (2013) Rajamani <i>et al.</i> (2013)
			NS	Rao and Gopinath (2013) Asha <i>et al.</i> (2015)
		Negative	S	Rajanna <i>et al.</i> (2011) Pujer <i>et al.</i> (2014)
			NS	Kumar <i>et al.</i> (2010) Haritha (2011) Mohan (2011)
12	Bundle strength	Positive	S	Kumar <i>et al.</i> (2010) Bazi (2011) Rao and Gopinath (2013) Asha <i>et al.</i> (2015)
			NS	Kumar <i>et al.</i> (2010) Rajanna (2010) Mohan (2011) Venkatesh (2012)
		Negative	S	Rao and Rajamani (2009) Kumar and Ravikesavan (2010) Haritha (2011) Anitha (2013)
			NS	Rajamani <i>et al.</i> (2013)
13	Uniformity ratio	Positive	S	Neelima <i>et al.</i> (2005) Anitha (2013) Rajamani <i>et al.</i> (2013) Pujer <i>et al.</i> (2014)
			NS	Raju (2005) Srinivasulu (2009) Bazi (2011) Rao and Gopinath (2013) Asha <i>et al.</i> (2015)
		Negative	S	Vijayalaxmi <i>et al.</i> (2008) Anandan (2009)
			NS	Haritha (2011) Kishore <i>et al.</i> (2011) Mohan (2011) Rajanna <i>et al.</i> (2011)

Table 2.3 (contd..)

S. No.	Character	Association	S/NS	Reference
14	Lint yield per plant	Positive	S	Pratap <i>et al.</i> (2007) Vijayalaxmi <i>et al.</i> (2008) Mahantesh (2009) Kumar and Ravikesavan (2010) Bazi (2011) Rajanna <i>et al.</i> (2011) Venkatesh (2012) Vineela <i>et al.</i> (2012a) Anitha (2013) Rao and Gopinath (2013) Erande <i>et al.</i> (2014) Reddy <i>et al.</i> (2015)

Note: S: Significant, NS: Non-significant

Table 2.5. Review of literature on direct effects of component characters on seed cotton yield in cotton (*Gossypium hirsutum* L.)

S.No.	Character	Positive Direct effect	Negative Direct effect
1	Days to 50% flowering	Muthu <i>et al.</i> (2004) Tuteja <i>et al.</i> (2006) Padmavathi (2008) Rao <i>et al.</i> (2009a) Kumar <i>et al.</i> (2010) Venkateswarulu <i>et al.</i> (2010b) Rajanna <i>et al.</i> (2011) Vineela (2011) Rajamani <i>et al.</i> (2013) Asha <i>et al.</i> (2015)	Kaushik and Kapoor (2006) Annapurve <i>et al.</i> (2007) Kale <i>et al.</i> (2007) Sakthi <i>et al.</i> (2007) Vijayalaxmi <i>et al.</i> (2008) Anandan (2009) Haritha (2011) Alkuddsi <i>et al.</i> (2013) Anitha (2013)
2	Plant height	Muthu <i>et al.</i> (2004) Rauf <i>et al.</i> (2004) Kaushik and Kapoor (2006) Sakthi <i>et al.</i> (2007) Venkateswarulu <i>et al.</i> (2010b) Haritha (2011) Rajanna <i>et al.</i> (2011) Venkatesh (2012) Wang <i>et al.</i> (2012) Erande <i>et al.</i> (2014)	Raju (2005) Verma <i>et al.</i> (2006) Annapurve <i>et al.</i> (2007) Kale <i>et al.</i> (2007) Vijayalaxmi <i>et al.</i> (2008) Rasheed <i>et al.</i> (2009) Kumar <i>et al.</i> (2010) Vineela (2011) Alkuddsi <i>et al.</i> (2013) Anitha (2013) Rajamani <i>et al.</i> (2013)
3	Number of monopodia per plant	Muthu <i>et al.</i> (2004) Rauf <i>et al.</i> (2004) Iqbal <i>et al.</i> (2006) Vijayalaxmi <i>et al.</i> (2008) Ekinci <i>et al.</i> (2010) Shazia <i>et al.</i> (2010) Srinivasulu <i>et al.</i> (2010b) Rajanna <i>et al.</i> (2011) Venkatesh (2012) Alkuddsi <i>et al.</i> (2013) Anitha (2013) Erande <i>et al.</i> (2014)	Kaushik and Kapoor (2006) Tuteja <i>et al.</i> (2006) Verma <i>et al.</i> (2006) Annapurve <i>et al.</i> (2007) Kale <i>et al.</i> (2007) Padmavathi (2008) Vijayalaxmi (2008) Sarada <i>et al.</i> (2010) Tulasi <i>et al.</i> (2012) Vineela <i>et al.</i> (2012a) Rajamani <i>et al.</i> (2013) Reddy <i>et al.</i> (2015)

Table 2.5 (contd..)

S. No.	Character	Positive Direct effect	Negative Direct effect
4	Number of sympodia per plant	<i>Neelima et al. (2005)</i> <i>Verma et al. (2006)</i> <i>Annapurve et al. (2007)</i> <i>Kale et al. (2007)</i> <i>Sakthi et al. (2007)</i> <i>Vijayalaxmi et al. (2008)</i> <i>Ekinci et al. (2010)</i> <i>Kumar et al. (2010)</i> <i>Shazia et al. (2010)</i> <i>Srinivasulu et al. (2010b)</i> <i>Haritha (2011)</i> <i>Vineela (2011)</i> <i>Venkatesh (2012)</i> <i>Wang et al. (2012)</i> <i>Alkuddsi et al. (2013)</i> <i>Anitha (2013)</i> <i>Rajamani et al. (2013)</i> <i>Erande et al. (2014)</i>	<i>Muthu et al. (2004)</i> <i>Rauf et al. (2004)</i> <i>Raju (2005)</i> <i>Tuteja et al. (2006)</i> <i>Alishah et al. (2008)</i> <i>Karademir et al. (2009)</i> <i>Rao et al. (2009a)</i> <i>Rasheed et al. (2009)</i> <i>Venkateswarlu et al. (2010b)</i> <i>Bazi (2011)</i> <i>Reddy et al. (2015)</i>
5	Number of bolls per plant	<i>Rauf et al. (2004)</i> <i>Kaushik and Kapoor (2006)</i> <i>Annapurve et al. (2007)</i> <i>Kale et al. (2007)</i> <i>Pratap et al. (2007)</i> <i>Sakthi et al. (2007)</i> <i>Vijayalaxmi et al. (2008)</i> <i>Ekinci et al. (2010)</i> <i>Kumar et al. (2010)</i> <i>Shazia et al. (2010)</i> <i>Srinivasulu et al. (2010b)</i> <i>Thiyagu et al. (2010)</i> <i>Haritha (2011)</i> <i>Tulasi et al. (2012)</i> <i>Venkatesh (2012)</i> <i>Wang et al. (2012)</i> <i>Anitha (2013)</i> <i>Rajamani et al. (2013)</i> <i>Rao and Gopinath (2013)</i> <i>Erande et al. (2014)</i>	<i>Tuteja et al. (2006)</i> <i>Alishah et al. (2008)</i> <i>Karademir et al. (2009)</i> <i>Vineela (2011)</i> <i>Alkuddsi et al. (2013)</i>
6	Boll weight	<i>Gururajan and Sundar (2004)</i> <i>Muthu et al. (2004)</i> <i>Rauf et al. (2004)</i> <i>Raju (2005)</i> <i>Iqbal et al. (2006)</i> <i>Annapurve et al. (2007)</i> <i>Kale et al. (2007)</i> <i>Sakthi et al. (2007)</i>	<i>Verma et al. (2006)</i> <i>Alishah et al. (2008)</i> <i>Vijayalaxmi (2008)</i> <i>Karademir et al. (2009)</i> <i>Rao et al. (2009a)</i> <i>Rasheed et al. (2009)</i>

Table 2.5 (contd.)

S. No.	Character	Positive Direct effect	Negative Direct effect
6	Boll weight	Vijayalaxmi <i>et al.</i> (2008) Ekinci <i>et al.</i> (2010) Kumar <i>et al.</i> (2010) Shazia <i>et al.</i> (2010) Srinivasulu <i>et al.</i> (2010b) Thiyagu <i>et al.</i> (2010) Haritha (2011) Mohan (2011) Venkatesh (2012) Wang <i>et al.</i> (2012) Vineela <i>et al.</i> (2012a) Alkuddsi <i>et al.</i> (2013) Rajamani <i>et al.</i> (2013) Rao and Gopinath (2013) Erande <i>et al.</i> (2014)	Tulasi <i>et al.</i> (2012) Anitha (2013) Vanaja (2014)
7	Seed index	Kaushik and Kapoor (2006) Vijayalaxmi <i>et al.</i> (2008) Kumar <i>et al.</i> (2010) Sarada <i>et al.</i> (2010) Rajanna <i>et al.</i> (2011) Tulasi <i>et al.</i> (2012) Venkatesh (2012) Rajamani <i>et al.</i> (2013) Erande <i>et al.</i> (2014) Asha <i>et al.</i> (2015)	Gururajan and Sundar (2004) Raju (2005) Kale <i>et al.</i> (2007) Rasheed <i>et al.</i> (2009) Haritha (2011) Vineela (2011) Alkuddsi <i>et al.</i> (2013) Anitha (2013)
8	Lint index	Gururajan and Sundar (2004) Neelima <i>et al.</i> (2005) Raju (2005) Sakthi <i>et al.</i> (2007) Vijayalaxmi <i>et al.</i> (2008) Kumar <i>et al.</i> (2010) Haritha (2011) Alkuddsi <i>et al.</i> (2013) Rajamani <i>et al.</i> (2013) Erande <i>et al.</i> (2014)	Muthu <i>et al.</i> (2004) Kaushik and Kapoor (2006) Pratap <i>et al.</i> (2007) Padmavathi (2008) Sarada <i>et al.</i> (2010) Venkateswarlu <i>et al.</i> (2010b) Vineela (2011) Tulasi <i>et al.</i> (2012) Venkatesh (2012) Anitha (2013)
9	Ginning outturn	Muthu <i>et al.</i> (2004) Kaushik and Kapoor (2006) Tuteja <i>et al.</i> (2006) Kale <i>et al.</i> (2007) Pratap <i>et al.</i> (2007)	Gururajan and Sundar (2004) Raju (2005) Iqbal <i>et al.</i> (2006) Annapurve <i>et al.</i> (2007) Sakthi <i>et al.</i> (2007)

Table 2.5 (contd..)

S. No.	Character	Positive Direct effect	Negative Direct effect
9	Ginning outturn	Sarada <i>et al.</i> (2010) Tulasi <i>et al.</i> (2012) Wang <i>et al.</i> (2012) Anitha (2013) Rao and Gopinath (2013) Erande <i>et al.</i> (2014)	Vijayalaxmi <i>et al.</i> (2008) Kumar <i>et al.</i> (2010) Shazia <i>et al.</i> (2010) Venkateswarlu <i>et al.</i> (2010b) Haritha (2011) Vineela (2011) Venkatesh (2012) Alkuddsi <i>et al.</i> (2013) Rajamani <i>et al.</i> (2013) Asha <i>et al.</i> (2015)
10	2.5% span length	Muthu <i>et al.</i> (2004) Raju (2005) Kaushik and Kapoor (2006) Tuteja <i>et al.</i> (2006) Kale <i>et al.</i> (2007) Kumar <i>et al.</i> (2010) Sarada <i>et al.</i> (2010) Rajanna <i>et al.</i> (2011) Vineela (2011) Rajamani <i>et al.</i> (2013) Rao and Gopinath (2013) Erande <i>et al.</i> (2014) Asha <i>et al.</i> (2015)	Verma <i>et al.</i> (2006) Sakthi <i>et al.</i> (2007) Padmavathi (2008) Rao <i>et al.</i> (2009a) Venkateswarlu <i>et al.</i> (2010b) Haritha (2011) Venkatesh (2012) Anitha (2013)
11	Micronaire value	Muthu <i>et al.</i> (2004) Neelima <i>et al.</i> (2005) Murthy <i>et al.</i> (2006) Pratap <i>et al.</i> (2007) Vijayalaxmi <i>et al.</i> (2008) Kumar <i>et al.</i> (2010) Sarada <i>et al.</i> (2010) Rajanna <i>et al.</i> (2011) Anitha (2013) Rajamani <i>et al.</i> (2013) Rao and Gopinath (2013) Erande <i>et al.</i> (2014)	Gururajan and Sundar (2004) Raju (2005) Verma <i>et al.</i> (2006) Anandan (2009) Rao <i>et al.</i> (2009a) Venkateswarlu <i>et al.</i> (2010b) Bazi (2011) Haritha (2011) Venkatesh (2012) Vanaja (2014)
12	Bundle strength	Murthy <i>et al.</i> (2006) Sakthi <i>et al.</i> (2007) Padmavathi (2008) Sarada <i>et al.</i> (2010) Rajanna <i>et al.</i> (2011) Anitha (2013)	Raju (2005) Vijayalaxmi <i>et al.</i> (2008) Kumar <i>et al.</i> (2010) Venkateswarlu <i>et al.</i> (2010b) Vineela (2011) Venkatesh (2012) Rajamani <i>et al.</i> (2013) Rao and Gopinath (2013) Pujer <i>et al.</i> (2014) Reddy <i>et al.</i> (2015)

Table 2.5 (contd..)

S. No.	Character	Positive Direct effect	Negative Direct effect
13	Uniformity ratio	Raju (2005) Murthy <i>et al.</i> (2006) Vijayalaxmi <i>et al.</i> (2008) Srinivasulu <i>et al.</i> (2010b) Rajanna <i>et al.</i> (2011) Anitha (2013) Rajamani <i>et al.</i> (2013) Rao and Gopinath (2013) Erande <i>et al.</i> (2014)	Muthu <i>et al.</i> (2004) Pratap <i>et al.</i> (2007) Sakthi <i>et al.</i> (2007) Anandan (2009) Sarada <i>et al.</i> (2010) Haritha (2011) Venkatesh (2012) Reddy <i>et al.</i> (2015)
14	Lint yield per plant	Pratap <i>et al.</i> (2007) Vijayalaxmi <i>et al.</i> (2008) Rajanna <i>et al.</i> (2011) Venkatesh (2012) Vineela <i>et al.</i> (2012a) Anitha (2013) Rao and Gopinath (2013) Erande <i>et al.</i> (2014) Reddy <i>et al.</i> (2015)	-

Table 2.6. Review of literature on gene action governing yield and yield components in cotton (*Gossypium hirsutum* L.)

S.No.	Character	Additive	Non-additive	Additive and Non-additive
1.	Days to 50% flowering	Reshmi <i>et al.</i> (2007) Kalpande <i>et al.</i> (2008) Wankhade <i>et al.</i> (2008) Shinde <i>et al.</i> (2012) Anitha (2013)	Narisireddy and Satyanarayana (2004) Patel <i>et al.</i> (2005) Subramanian <i>et al.</i> (2005) Kiani <i>et al.</i> (2007) Kamboh <i>et al.</i> (2008) Preetha and Raveendran (2008) Deosarkar <i>et al.</i> (2009b) Rajanna (2010) Patil <i>et al.</i> (2011b) Amir <i>et al.</i> (2012) Haritha <i>et al.</i> (2012) Vineela <i>et al.</i> (2012b) Alkuddsi <i>et al.</i> (2013) Simon <i>et al.</i> (2013)	Sivaprasad <i>et al.</i> (2004a) Giri <i>et al.</i> (2006a) Venkatesh (2012)
2.	Plant height (cm)	Patel <i>et al.</i> (2005) Subramanian <i>et al.</i> (2005) Ilyas <i>et al.</i> (2007) Bhaskaran and Ravikesavan (2008) Kalpande <i>et al.</i> (2008) Soomro <i>et al.</i> (2010) Haritha <i>et al.</i> (2012) Natera <i>et al.</i> (2012) Tariq and Uzair (2012)	Ilyas <i>et al.</i> (2007) Kamboh <i>et al.</i> (2008) Deosarkar <i>et al.</i> (2009b) Mohammad <i>et al.</i> (2010) Rajanna (2010) Patil <i>et al.</i> (2011b) Patel <i>et al.</i> (2012) Venkatesh (2012) Vineela <i>et al.</i> (2012b) Alkuddsi <i>et al.</i> (2013) Anitha (2013) Simon <i>et al.</i> (2013)	Rathore <i>et al.</i> (2004) Sundaravadivelu <i>et al.</i> (2005) Giri <i>et al.</i> (2006a) Kiani <i>et al.</i> (2007)

Table 2.6 (cont.)

S.No.	Character	Additive	Non-additive	Additive and Non-additive
3	Number of monopodia per plant	Raju (2005) Kiani <i>et al.</i> (2007) Mohammad <i>et al.</i> (2010) Mohan (2011)	Narisireddy and Satyanarayana (2004) Patel <i>et al.</i> (2005) Deosarkar <i>et al.</i> (2009b) Mahantesh <i>et al.</i> (2010) Rajanna (2010) Patil <i>et al.</i> (2011b) Shinde <i>et al.</i> (2012) Vineela <i>et al.</i> (2012b) Alkuddsi <i>et al.</i> (2013) Anitha (2013)	Sundaravadivelu <i>et al.</i> (2005) Giri <i>et al.</i> (2006a) Patel <i>et al.</i> (2009) Wandhare <i>et al.</i> (2010a) Tariq and Uzair (2012) Venkatesh (2012)
4	Number of sympodia per plant	Bhaskaran and Ravikesavan (2008) Jatoi <i>et al.</i> (2011) Mohan (2011) Dhanalakshmi <i>et al.</i> (2012) Haritha <i>et al.</i> (2012) Shinde <i>et al.</i> (2012) Tariq and Uzair (2012)	Sivaprasad <i>et al.</i> (2004a) Patel <i>et al.</i> (2005) Subramanian <i>et al.</i> (2005) Kiani <i>et al.</i> (2007) Kamboh <i>et al.</i> (2008) Wankhade <i>et al.</i> (2008) Deosarkar <i>et al.</i> (2009b) Patel <i>et al.</i> (2009) Mahantesh <i>et al.</i> (2010) Mohammad <i>et al.</i> (2010) Rajanna (2010) Patil <i>et al.</i> (2011b) Vineela <i>et al.</i> (2012b) Alkuddsi <i>et al.</i> (2013) Anitha (2013) Vanaja (2014)	Rathore <i>et al.</i> (2004) Sundaravadivelu <i>et al.</i> (2005) Giri <i>et al.</i> (2006a) Patel <i>et al.</i> (2009) Wandhare <i>et al.</i> (2010a) Venkatesh (2012)

Table 2.6 (cont.)

S.No.	Character	Additive	Non-additive	Additive and Non-additive
5	Number of bolls per plant	Bhaskaran and Ravikesavan (2008) Kalpande <i>et al.</i> (2008) Patel <i>et al.</i> (2009) Soomro <i>et al.</i> (2010) Jatoi <i>et al.</i> (2011) Mohan (2011) Tariq and Uzair (2012) Rao and Gopinath (2013)	Verma <i>et al.</i> (2004) Subramanian <i>et al.</i> (2005) Ilyas <i>et al.</i> (2007) Kamboh <i>et al.</i> (2008) Wankhade <i>et al.</i> (2008) Deosarkar <i>et al.</i> (2009b) Naqib <i>et al.</i> (2009) Mahantesh <i>et al.</i> (2010) Mohammad <i>et al.</i> (2010) Rajanna (2010) Patil <i>et al.</i> (2011b) Amir <i>et al.</i> (2012) Haritha <i>et al.</i> (2012) Patel <i>et al.</i> (2012) Shinde <i>et al.</i> (2012) Venkatesh (2012) Vineela <i>et al.</i> (2012 b) Alkuddsi <i>et al.</i> (2013) Nassar (2013) Simon <i>et al.</i> (2013)	Rathore <i>et al.</i> (2004) Giri <i>et al.</i> (2006a) Kiani <i>et al.</i> (2007) Panhwar <i>et al.</i> (2008) Patel <i>et al.</i> (2009) Bbebe <i>et al.</i> (2010) Wandhare <i>et al.</i> (2010a) Anitha (2013)
6	Boll weight (g)	Reshmi <i>et al.</i> (2007) Bhaskaran and Ravikesavan (2008) Kalpande <i>et al.</i> (2008) Kamboh <i>et al.</i> (2008) Patel <i>et al.</i> (2009) Mohammad <i>et al.</i> (2010) Singh <i>et al.</i> (2010)	Ilyas <i>et al.</i> (2007) Wankhade <i>et al.</i> (2008) Deosarkar <i>et al.</i> (2009b) Vemanna and Kajjidoni (2009) Senthilkumar <i>et al.</i> (2010) Soomro <i>et al.</i> (2010) Rajanna (2010)	Panhwar <i>et al.</i> (2008) Kiani <i>et al.</i> (2007) Gamal <i>et al.</i> (2009) Patel <i>et al.</i> (2009) Bbebe <i>et al.</i> (2010)

Table 2.6 (cont.)

S.No.	Character	Additive	Non-additive	Additive and Non-additive
6	Boll weight (g)	Amir <i>et al.</i> (2012) Haritha <i>et al.</i> (2012) Natera <i>et al.</i> (2012) Patel <i>et al.</i> (2012) Santoshkumar <i>et al.</i> (2012) Tariq and Uzair (2012) Venkatesh (2012) Nassar (2013) Rao and Gopinath (2013)	Mohan (2011) Patil <i>et al.</i> (2011b) Shinde <i>et al.</i> (2012) Vineela <i>et al.</i> (2012 b) Alkuddsi <i>et al.</i> (2013) Anitha (2013)	Wandhare <i>et al.</i> (2010a) Rajamani <i>et al.</i> (2012)
7	Seed index (g)	Kalpande <i>et al.</i> (2008) Patel <i>et al.</i> (2009) Mohammad <i>et al.</i> (2009) Wandhare <i>et al.</i> (2010 b) Nassar (2013)	Deosarkar <i>et al.</i> (2009b) Mahantesh <i>et al.</i> (2010) Rajanna (2010) Soomro <i>et al.</i> (2010) Mohan (2011) Patil <i>et al.</i> (2011b) Venkatesh (2012) Vineela <i>et al.</i> (2012 b) Alkuddsi <i>et al.</i> (2013) Anitha (2013)	Panhwar <i>et al.</i> (2008) Haritha <i>et al.</i> (2012)
8	Lint index (g)	Kalpande <i>et al.</i> (2008) Mohammad <i>et al.</i> (2009) Wandhare <i>et al.</i> (2010b) Dhanalakshmi <i>et al.</i> (2012) Santoshkumar <i>et al.</i> (2012)	Preetha and Raveendran (2008) Basal <i>et al.</i> (2009) Vemanna and Kajjidoni (2009) Mahantesh <i>et al.</i> (2010) Rajanna (2010) Mohan (2011)	Gamal <i>et al.</i> (2009)

Table 2.6 (cont.)

S.No.	Character	Additive	Non-additive	Additive and Non-additive
8	Lint index (g)		Patil <i>et al.</i> (2011b) Haritha <i>et al.</i> (2012) Venkatesh (2012) Vineela <i>et al.</i> (2012 b) Alkuddsi <i>et al.</i> (2013) Anitha (2013) Vanaja (2014)	
9	Ginning outturn (%)	Bhaskaran and Ravikesavan (2008) Kalpande <i>et al.</i> (2008) Patel <i>et al.</i> (2009) Deshmukh <i>et al.</i> (2010) Wandhare <i>et al.</i> (2010b) Haritha <i>et al.</i> (2012) Rao and Gopinath (2013)	Kamboh <i>et al.</i> (2008) Deosarkar <i>et al.</i> (2009b) Karademir <i>et al.</i> (2009) Mahantesh <i>et al.</i> (2010) Rajanna (2010) Mohan (2011) Patil <i>et al.</i> (2011b) Patel <i>et al.</i> (2012) Venkatesh (2012) Vineela <i>et al.</i> (2012b) Alkuddsi <i>et al.</i> (2013) Anitha (2013) Vanaja (2014)	Panhwar <i>et al.</i> (2008) Patel <i>et al.</i> (2009) Bbebe <i>et al.</i> (2010) Dhanalakshmi (2011)
10	2.5% span length (mm)	Kalpande <i>et al.</i> (2008) Kamboh <i>et al.</i> (2008) Karademir <i>et al.</i> (2009) Naqib <i>et al.</i> (2010) Wandhare <i>et al.</i> (2010b) Mohan (2011)	Patel <i>et al.</i> (2006) Ilyas <i>et al.</i> (2007) Lukange <i>et al.</i> (2007) Kumar and Ravikesavan (2008) Vemanna and Kajjidoni (2009) Rajanna (2010)	Natera <i>et al.</i> (2012) Venkatesh (2012) Rao and Gopinath (2013)

Table 2.6 (cont.)

S.No.	Character	Additive	Non-additive	Additive and Non-additive
10	2.5% span length (mm)	Patil <i>et al.</i> (2011b) Amir <i>et al.</i> (2012) Anitha (2013)	Mahantesh <i>et al.</i> (2010) Singh <i>et al.</i> (2010) Haritha <i>et al.</i> (2012) Vineela <i>et al.</i> (2012b) Vanaja (2014)	
11	Micronaire value (10 ⁻⁶ g/inch)	Kalpande <i>et al.</i> (2008) Kamboh <i>et al.</i> (2008) Wandhare <i>et al.</i> (2010b) Anitha (2013)	Lukange <i>et al.</i> (2007) Kumar and Ravikesavan (2008) Basal <i>et al.</i> (2009) Vemanna and Kajjidoni (2009) Mahantesh <i>et al.</i> (2010) Rajanna (2010) Singh <i>et al.</i> (2010) Dhanalakshmi (2011) Mohan (2011) Patil <i>et al.</i> (2011b) Amir <i>et al.</i> (2012) Vineela <i>et al.</i> (2012b) Vanaja (2014)	Haritha <i>et al.</i> (2012) Natera <i>et al.</i> (2012) Venkatesh (2012) Rao and Gopinath (2013)
12	Bundle strength (g/tex)	Karademir <i>et al.</i> (2007) Kalpande <i>et al.</i> (2008) Basal <i>et al.</i> (2009) Wandhare <i>et al.</i> (2010b) Amir <i>et al.</i> (2012) Anitha (2013)	Ilyas <i>et al.</i> (2007) Lukange <i>et al.</i> (2007) Faqir and Naeem (2008) Kumar and Ravikesavan (2008) Karademir <i>et al.</i> (2009) Hussain <i>et al.</i> (2010) Mahantesh <i>et al.</i> (2010) Rajanna (2010)	Natera <i>et al.</i> (2012) Venkatesh (2012) Rao and Gopinath (2013) Vanaja (2014)

Table 2.6 (cont.)

S.No.	Character	Additive	Non-additive	Additive and Non-additive
12	Bundle strength (g/tex)		Mohan (2011) Haritha <i>et al.</i> (2012) Vineela <i>et al.</i> (2012b)	
13	Uniformity ratio	Mohammad <i>et al.</i> (2009) Deshmukh <i>et al.</i> (2010) Wandhare <i>et al.</i> (2010b)	Manickam and Gururajan (2004) Kumar and Ravikesavan (2008) Preetha and Raveendran (2008) Basal <i>et al.</i> (2009) Karademir <i>et al.</i> (2009) Vemanna and Kajjidoni (2009) Hussain <i>et al.</i> (2010) Mohan (2011) Patil <i>et al.</i> (2011b) Vineela <i>et al.</i> (2012b) Anitha (2013) Rao and Gopinath (2013) Vanaja (2014)	Karademir <i>et al.</i> (2007) Haritha <i>et al.</i> (2012) Venkatesh (2012)
14	Seed cotton yield per plant (g)	Karademir <i>et al.</i> (2007) Reshmi <i>et al.</i> (2007) Bhaskaran and Ravikesavan (2008) Naqib <i>et al.</i> (2010) Patel <i>et al.</i> (2009) Bbebe <i>et al.</i> (2010) Mohammad <i>et al.</i> (2010) Singh <i>et al.</i> (2010) Soomro <i>et al.</i> (2010) Wandhare <i>et al.</i> (2010b)	Ilyas <i>et al.</i> (2007) Kalpande <i>et al.</i> (2008) Kamboh <i>et al.</i> (2008) Kumar and Ravikesavan (2008) Deosarkar <i>et al.</i> (2009b) Karademir <i>et al.</i> (2009) Mahantesh <i>et al.</i> (2010) Rajanna (2010) Dhanalakshmi (2011) Patil <i>et al.</i> (2011b)	Giri <i>et al.</i> (2006 a) Panhwar <i>et al.</i> (2008) Gamal <i>et al.</i> (2009) Patel <i>et al.</i> (2009) Wandhare <i>et al.</i> (2010a) Vineela (2011) Natera <i>et al.</i> (2012) Venkatesh (2012)

Table 2.6 (cont.)

S.No.	Character	Additive	Non-additive	Additive and Non-additive
14	Seed cotton yield per plant (g)	Haritha (2011) Jatoi <i>et al.</i> (2011) Mohan (2011) Amir <i>et al.</i> (2012) Tariq and Uzair (2012) Anitha (2013) Rao and Gopinath (2013)	Patel <i>et al.</i> (2012) Shinde <i>et al.</i> (2012) Vineela <i>et al.</i> (2012b) Alkuddsi <i>et al.</i> (2013) Nassar (2013) Vanaja (2014)	
15	Lint yield per plant (g)	Patel <i>et al.</i> (2009) Anitha (2013) Rao and Gopinath (2013)	Karademir <i>et al.</i> (2007) Deosarkar <i>et al.</i> (2009b) Karademir <i>et al.</i> (2009) Rajanna (2010) Patel <i>et al.</i> (2012) Vineela <i>et al.</i> (2012b) Nassar (2013) Simon <i>et al.</i> (2013) Vanaja (2014)	Gamal <i>et al.</i> (2009) Venkatesh (2012)

Table 2.7. Review of literature on heterosis over mid parent (Relative heterosis), better parent (Heterobeltiosis) and standard check (Standard heterosis) for seed cotton yield and yield components in hybrids of cotton (*Gossypium hirsutum*L.)

S. No.	Character	Relative heterosis	Heterobeltiosis	Standard heterosis
1	Days to 50% flowering	Dukre <i>et al.</i> (2007) Ganapathy and Nadarajan (2008) Deosarkar <i>et al.</i> (2009a) Kaushik and Sastry (2011)	Ganapathy and Nadarajan (2008) Deosarkar <i>et al.</i> (2009a) Kaushik and Sastry (2011) Patil <i>et al.</i> (2011a)	Preetha and Raveendran (2008) Deosarkar <i>et al.</i> (2009a) Rajanna (2010) Patil <i>et al.</i> (2011a) Vineela <i>et al.</i> (2012b)
2	Plant height (cm)	Abdel <i>et al.</i> (2007) Dukre <i>et al.</i> (2007) Maisuria <i>et al.</i> (2007) Ganapathy and Nadarajan (2008) Deosarkar <i>et al.</i> (2009a) Saifullah <i>et al.</i> (2009) Mohammad <i>et al.</i> (2010) Kaushik and Sastry (2011) Patel <i>et al.</i> (2012) Punitha <i>et al.</i> (2012) Sekhar <i>et al.</i> (2012) Kumar and Ravikesavan (2013)	Abdel <i>et al.</i> (2007) Ganapathy and Nadarajan (2008) Deosarkar <i>et al.</i> (2009a) Saifullah <i>et al.</i> (2009) Wankhade <i>et al.</i> (2009) Kaushik and Sastry (2011) Naqib (2011) Patil <i>et al.</i> (2011a) Patel <i>et al.</i> (2012) Punitha <i>et al.</i> (2012) Sekhar <i>et al.</i> (2012) Kumar and Ravikesavan (2013)	Maisuria <i>et al.</i> (2007) Preetha and Raveendran (2008) Deosarkar <i>et al.</i> (2009a) Patel <i>et al.</i> (2009) Wankhade <i>et al.</i> (2009) Rajanna (2010) Naqib (2011) Patil <i>et al.</i> (2011a) Patel <i>et al.</i> (2012) Sekhar <i>et al.</i> (2012) Vineela <i>et al.</i> (2012b) Alkuddsi <i>et al.</i> (2013)
3	Number of monopodia per plant	Maisuria <i>et al.</i> (2007) Deosarkar <i>et al.</i> (2009a) Mohammad <i>et al.</i> (2010) Kaushik and Sastry (2011) Sekhar <i>et al.</i> (2012)	Maisuria <i>et al.</i> (2007) Deosarkar <i>et al.</i> (2009a) Kaushik and Sastry (2011) Sekhar <i>et al.</i> (2012)	Maisuria <i>et al.</i> (2007) Deosarkar <i>et al.</i> (2009a) Mahantesh (2009) Rajanna (2010) Mohan (2011) Tuteja <i>et al.</i> (2011) Sekhar <i>et al.</i> (2012) Vineela <i>et al.</i> (2012b) Alkuddsi <i>et al.</i> (2013)

Table 2.7(cont.)

S. No.	Character	Relative heterosis	Heterobeltiosis	Standard heterosis
4	Number of sympodia per plant	Dukre <i>et al.</i> (2007) Maisuria <i>et al.</i> (2007) Ganapathy and Nadarajan (2008) Deosarkar <i>et al.</i> (2009a) Saifullah <i>et al.</i> (2009) Mohammad <i>et al.</i> (2010) Kaushik and Sastry (2011) Sekhar <i>et al.</i> (2012) Kumar and Ravikesavan (2013)	Maisuria <i>et al.</i> (2007) Ganapathy and Nadarajan (2008) Deosarkar <i>et al.</i> (2009a) Saifullah <i>et al.</i> (2009) Wankhade <i>et al.</i> (2009) Kaushik and Sastry (2011) Naqib (2011) Patil <i>et al.</i> (2011a) Nidagundi <i>et al.</i> (2012) Sekhar <i>et al.</i> (2012) Kumar and Ravikesavan (2013)	Preetha and Raveendran (2008) Deosarkar <i>et al.</i> (2009a) Patil <i>et al.</i> (2009) Wankhade <i>et al.</i> (2009) Rajanna (2010) Naqib (2011) Patil <i>et al.</i> (2011a) Tuteja <i>et al.</i> (2011) Javendra and Amit (2012) Sekhar <i>et al.</i> (2012) Vineela <i>et al.</i> (2012b) Alkuddsi <i>et al.</i> (2013)
5	Number of bolls per plant	Abdel <i>et al.</i> (2007) Dukre <i>et al.</i> (2007) Maisuria <i>et al.</i> (2007) Ganapathy and Nadarajan (2008) Pole <i>et al.</i> (2008) Deosarkar <i>et al.</i> (2009a) Saifullah <i>et al.</i> (2009) Basamma <i>et al.</i> (2010) Mohammad <i>et al.</i> (2010) Kaushik and Sastry (2011) Maria <i>et al.</i> (2012) Patel <i>et al.</i> (2012) Punitha <i>et al.</i> (2012) Sekhar <i>et al.</i> (2012) Kumar and Ravikesavan (2013)	Abdel <i>et al.</i> (2007) Maisuria <i>et al.</i> (2007) Ganapathy and Nadarajan (2008) Pole <i>et al.</i> (2008) Saifullah <i>et al.</i> (2009) Deosarkar <i>et al.</i> (2009a) Basamma <i>et al.</i> (2010) Kaushik and Sastry (2011) Naqib (2011) Patil <i>et al.</i> (2011a) Maria <i>et al.</i> (2012) Patel <i>et al.</i> (2012) Punitha <i>et al.</i> (2012) Sekhar <i>et al.</i> (2012) Kumar and Ravikesavan (2013)	Ganapathy and Nadarajan (2008) Pole <i>et al.</i> (2008) Deosarkar <i>et al.</i> (2009a) Patil <i>et al.</i> (2009) Wankhade <i>et al.</i> (2009) Basamma <i>et al.</i> (2010) Tuteja <i>et al.</i> (2011) Mohan (2011) Patil <i>et al.</i> (2011a) Javendra and Amit (2012) Patel <i>et al.</i> (2012) Sekhar <i>et al.</i> (2012) Vineela <i>et al.</i> (2012b) Alkuddsi <i>et al.</i> (2013) Amit <i>et al.</i> (2013)

Table 2.7(cont.)

S. No.	Character	Relative heterosis	Heterobeltiosis	Standard heterosis
6	Boll weight (g)	Abdel <i>et al.</i> (2007) Dukre <i>et al.</i> (2007) Maisuria <i>et al.</i> (2007) Pole <i>et al.</i> (2008) Deosarkar <i>et al.</i> (2009a) Basamma <i>et al.</i> (2010) Mohammad <i>et al.</i> (2010) Maria <i>et al.</i> (2012) Patel <i>et al.</i> (2012) Punitha <i>et al.</i> (2012) Sekhar <i>et al.</i> (2012) Kumar and Ravikesavan (2013)	Abdel <i>et al.</i> (2007) Maisuria <i>et al.</i> (2007) Pole <i>et al.</i> (2008) Deosarkar <i>et al.</i> (2009a) Wankhade <i>et al.</i> (2009) Naqib (2011) Patil <i>et al.</i> (2011a) Maria <i>et al.</i> (2012) Nidagundi <i>et al.</i> (2012) Patel <i>et al.</i> (2012) Punitha <i>et al.</i> (2012) Sekhar <i>et al.</i> (2012) Kumar and Ravikesavan (2013)	Preetha and Raveendran (2008) Patil <i>et al.</i> (2009) Wankhade <i>et al.</i> (2009) Basamma <i>et al.</i> (2010) Mohan (2011) Tuteja <i>et al.</i> (2011) Javendra and Amit (2012) Patel <i>et al.</i> (2012) Sekhar <i>et al.</i> (2012) Vineela <i>et al.</i> (2012b) Alkuddsi <i>et al.</i> (2013) Amit <i>et al.</i> (2013)
7	Seed index (g)	Dukre <i>et al.</i> (2007) Paulo <i>et al.</i> (2007) Pole <i>et al.</i> (2008) Deosarkar <i>et al.</i> (2009a) Punitha <i>et al.</i> (2012) Sekhar <i>et al.</i> (2012) Nassar (2013)	Deshpande <i>et al.</i> (2008) Pole <i>et al.</i> (2008) Deosarkar <i>et al.</i> (2009a) Patil <i>et al.</i> (2011a) Nidagundi <i>et al.</i> (2012) Punitha <i>et al.</i> (2012) Sekhar <i>et al.</i> (2012) Nassar (2013)	Pole <i>et al.</i> (2008) Deosarkar <i>et al.</i> (2009a) Rajanna (2010) Patil <i>et al.</i> (2011a) Tuteja <i>et al.</i> (2011) Vineela <i>et al.</i> (2012b) Alkuddsi <i>et al.</i> (2013) Jaiwar <i>et al.</i> (2013)
8	Lint index (g)	Dukre <i>et al.</i> (2007) Punitha <i>et al.</i> (2012) Sekhar <i>et al.</i> (2012)	Deshpande <i>et al.</i> (2008) Wankhade <i>et al.</i> (2009) Nidagundi <i>et al.</i> (2012) Punitha <i>et al.</i> (2012) Sekhar <i>et al.</i> (2012)	Wankhade <i>et al.</i> (2009) Rajanna (2010) Mohan (2011) Sekhar <i>et al.</i> (2012) Vineela <i>et al.</i> (2012b) Alkuddsi <i>et al.</i> (2013)

Table 2.7(cont.)

S. No.	Character	Relative heterosis	Heterobeltiosis	Standard heterosis
9	Ginning outturn (%)	Dukre <i>et al.</i> (2007) Pole <i>et al.</i> (2008) Deosarkar <i>et al.</i> (2009a) Basamma <i>et al.</i> (2010) Patel <i>et al.</i> (2012) Sekhar <i>et al.</i> (2012) Kumar and Ravikesavan (2013)	Pole <i>et al.</i> (2008) Deosarkar <i>et al.</i> (2009a) Wankhade <i>et al.</i> (2009) Patil <i>et al.</i> (2011a) Nidagundi <i>et al.</i> (2012) Patel <i>et al.</i> (2012) Sekhar <i>et al.</i> (2012) Kumar and Ravikesavan (2013)	Deosarkar <i>et al.</i> (2009a) Patil <i>et al.</i> (2009) Wankhade <i>et al.</i> (2009) Mohan (2011) Tuteja <i>et al.</i> (2011) Sekhar <i>et al.</i> (2012) Vineela <i>et al.</i> (2012b) Alkuddsi <i>et al.</i> (2013)
10	2.5% span length (mm)	Maisuria <i>et al.</i> (2007) Rajamani <i>et al.</i> (2009) Punitha <i>et al.</i> (2012) Sekhar <i>et al.</i> (2012) Kumar and Ravikesavan (2013)	Maisuria <i>et al.</i> (2007) Deshpande <i>et al.</i> (2008) Rajamani <i>et al.</i> (2009) Wankhade <i>et al.</i> (2009) Patil <i>et al.</i> (2011a) Punitha <i>et al.</i> (2012) Sekhar <i>et al.</i> (2012) Kumar and Ravikesavan (2013)	Maisuria <i>et al.</i> (2007) Rajamani <i>et al.</i> (2009) Jyothiba <i>et al.</i> (2010) Mohan (2011) Tuteja <i>et al.</i> (2011) Sekhar <i>et al.</i> (2012) Vineela <i>et al.</i> (2012b) Amit <i>et al.</i> (2013) Kumar and Ravikesavan (2013)
11	Micronaire value (10 ⁻⁶ g/inch)	Rajamani <i>et al.</i> (2009) Sekhar <i>et al.</i> (2012) Kumar and Ravikesavan (2013)	Maisuria <i>et al.</i> (2007) Rajamani <i>et al.</i> (2009) Patil <i>et al.</i> (2011a) Sekhar <i>et al.</i> (2012) Kumar and Ravikesavan (2013)	Maisuria <i>et al.</i> (2007) Preetha and Raveendran (2008) Rajanna (2010) Tuteja <i>et al.</i> (2011) Sekhar <i>et al.</i> (2012) Vineela <i>et al.</i> (2012b) Kumar and Ravikesavan (2013)

Table 2.7(cont.)

S. No.	Character	Relative heterosis	Heterobeltiosis	Standard heterosis
12	Bundle strength (g/tex)	Maisuria <i>et al.</i> (2007) Sekhar <i>et al.</i> (2012) Kumar and Ravikesavan (2013)	Maisuria <i>et al.</i> (2007) Deshpande <i>et al.</i> (2008) Wankhade <i>et al.</i> (2009) Sekhar <i>et al.</i> (2012) Kumar and Ravikesavan (2013)	Maisuria <i>et al.</i> (2007) Preetha and Raveendran (2008) Wankhade <i>et al.</i> (2009) Jyothiba <i>et al.</i> (2010) Mohan (2011) Tuteja <i>et al.</i> (2011) Sekhar <i>et al.</i> (2012) Vineela <i>et al.</i> (2012b) Alkuddsi <i>et al.</i> (2013) Kumar and Ravikesavan (2013)
13	Uniformity ratio	Maisuria <i>et al.</i> (2007) Rajamani <i>et al.</i> (2009) Sekhar <i>et al.</i> (2012) Kumar and Ravikesavan (2013)	Maisuria <i>et al.</i> (2007) Rajamani <i>et al.</i> (2009) Sekhar <i>et al.</i> (2012) Kumar and Ravikesavan (2013)	Khosla <i>et al.</i> (2007) Maisuria <i>et al.</i> (2007) Rajamani <i>et al.</i> (2009) Rajanna (2010) Mohan (2011) Sekhar <i>et al.</i> (2012) Vineela <i>et al.</i> (2012b) Kumar and Ravikesavan (2013)
14	Seed cotton yield per plant (g)	Dukre <i>et al.</i> (2007) Maisuria <i>et al.</i> (2007) Paulo <i>et al.</i> (2007) Ganapathy and Nadarajan (2008) Pole <i>et al.</i> (2008) Deosarkar <i>et al.</i> (2009a)	Maisuria <i>et al.</i> (2007) Pole <i>et al.</i> (2008) Deosarkar <i>et al.</i> (2009a) Rajamani <i>et al.</i> (2009) Saifullah <i>et al.</i> (2009) Wankhade <i>et al.</i> (2009)	Khosla <i>et al.</i> (2007) Maisuria <i>et al.</i> (2007) Reshmi <i>et al.</i> (2007) Preetha and Raveendran (2008) Zhang <i>et al.</i> (2008) Deosarkar <i>et al.</i> (2009a)

Table 2.7(cont.)

S. No.	Character	Relative heterosis	Heterobeltiosis	Standard heterosis
14	Seed cotton yield per plant (g)	Rajamani <i>et al.</i> (2009) Saifullah <i>et al.</i> (2009) Basamma <i>et al.</i> (2010) Kaushik and Sastry (2011) Balu <i>et al.</i> (2012) Maria <i>et al.</i> (2012) Patel <i>et al.</i> (2012) Punitha <i>et al.</i> (2012) Sekhar <i>et al.</i> (2012) Kumar and Ravikesavan (2013) Nassar (2013)	Basamma <i>et al.</i> (2010) Kaushik and Sastry (2011) Naqib (2011) Patil <i>et al.</i> (2011a) Balu <i>et al.</i> (2012) Javendra and Amit (2012) Maria <i>et al.</i> (2012) Nidagundi <i>et al.</i> (2012) Punitha <i>et al.</i> (2012) Sekhar <i>et al.</i> (2012) Kumar and Ravikesavan (2013) Nassar (2013)	Patel <i>et al.</i> (2009) Rajamani <i>et al.</i> (2009) Wankhade <i>et al.</i> (2009) Basamma <i>et al.</i> (2010) Rajanna (2010) Mohan (2011) Naqib (2011) Tuteja <i>et al.</i> (2011) Balu <i>et al.</i> (2012) Javendra and Amit (2012) Patel <i>et al.</i> (2012) Sekhar <i>et al.</i> (2012) Shinde <i>et al.</i> (2012) Vineela <i>et al.</i> (2012b) Amit <i>et al.</i> (2013) Jaiwar <i>et al.</i> (2013)
15	Lint yield per plant (g)	Paulo <i>et al.</i> (2007) Pole <i>et al.</i> (2008) Deosarkar <i>et al.</i> (2009a) Patel <i>et al.</i> (2012) Sekhar <i>et al.</i> (2012) Nassar (2013)	Pole <i>et al.</i> (2008) Deosarkar <i>et al.</i> (2009a) Nidagundi <i>et al.</i> (2012) Patel <i>et al.</i> (2012) Sekhar <i>et al.</i> (2012) Nassar (2013)	Pole <i>et al.</i> (2008) Deosarkar <i>et al.</i> (2009a) Javendra and Amit (2012) Patel <i>et al.</i> (2012) Sekhar <i>et al.</i> (2012) Vineela <i>et al.</i> (2012b)

Table 4.1. Analysis of variance for yield and yield components in cotton (*Gossypium hirsutum* L.) during *kharif*, 2013-14

Source	d.f.	Days to 50% flowering	Plant height (cm)	Number of monopodia per plant	Number of sympodia per plant	Number of bolls per plant	Boll weight (g)	Seed index (g)	Lint index (g)
Mean sum of squares									
Replications	2	1.376	67.684	0.076	4.342	28.574	0.022	0.009	0.098
Treatments	52	46.293**	539.923**	1.119**	9.033**	145.648**	0.775**	24.605**	0.785**
Error	104	4.024	51.354	0.050	1.951	35.826	0.029	0.491	0.117

Source	d.f.	Ginning outturn (%)	2.5% span length (mm)	Micronaire value (10 ⁻⁶ g/inch)	Bundle strength (g/tex)	Uniformity ratio	Seed cotton yield per plant (g)	Lint yield per plant (g)
Mean sum of squares								
Replications	2	0.459	0.254	0.005	0.527	2.668	512.668	80.363
Treatments	52	4.407**	8.050**	0.258**	1.546**	2.677**	4311.464**	597.775**
Error	104	0.938	0.231	0.041	0.176	0.940	583.981	72.301

**** Significant at 1% level**

Table 4.2. Estimates of mean, variability, heritability (broad sense) and genetic advance as per cent of mean for yield and its components in cotton (*Gossypium hirsutum* L.) during kharif, 2013-14

S. No.	Character	Mean	Range		Coefficient of variation		Heritability (broad sense) (%)	Genetic advance as per cent of mean
			Minimum	Maximum	PCV (%)	GCV (%)		
1	Days to 50% flowering	61.03	53.67	69.33	6.97	6.15	77.78	11.17
2	Plant height (cm)	129.44	99.20	157.23	11.31	9.86	76.03	17.71
3	Number of monopodia per plant	1.56	0.30	2.66	40.73	38.15	87.70	73.59
4	Number of sympodia per plant	17.11	14.63	20.87	12.13	8.98	54.75	13.69
5	Number of bolls per plant	54.67	37.67	71.33	15.57	11.07	50.54	16.21
6	Boll weight (g)	4.77	3.60	5.77	11.04	10.44	89.51	20.35
7	Seed index (g)	8.78	3.60	12.00	33.26	32.29	94.24	64.57
8	Lint index (g)	5.55	4.39	6.90	10.51	8.50	65.48	14.17
9	Ginning outturn (%)	34.53	30.57	36.17	4.20	3.11	55.20	4.76
10	2.5% span length (mm)	30.64	26.30	33.43	5.50	5.27	91.87	10.40
11	Micronaire value (10^{-6} g/inch)	4.06	3.40	4.63	8.30	6.61	63.42	10.84
12	Bundle strength (g/tex)	22.51	20.47	23.87	3.53	3.00	72.11	5.25
13	Uniformity ratio	47.02	45.00	49.00	2.62	1.62	38.11	2.06
14	Seed cotton yield per plant (g)	231.35	154.67	334.67	18.47	15.24	68.03	25.89
15	Lint yield per plant (g)	80.48	48.74	119.19	19.55	16.44	70.78	28.50

PCV = Phenotypic coefficient of variation

GCV = Genotypic coefficient of variation

Table 4.3. Phenotypic (above diagonal) and genotypic (below diagonal) correlation coefficients for 15 characters in intra-specific hybrids of cotton (*Gossypium hirsutum* L.) during *kharif*, 2013-14

Character	Days to 50% flowering	Plant height	Number of monopodia per plant	Number of sympodia per plant	Number of bolls per plant	Boll weight	Seed index	Lint index	Ginning outturn	2.5% span length	Micronaire value	Bundle strength	Uniformity ratio	Seed cotton yield per plant	Lint yield per plant
Days to 50% flowering	1.000	0.3208**	-0.1251	0.0326	0.0404	0.2028**	0.1733*	-0.2257**	-0.0439	0.0561	-0.0467	0.0939	0.0832	0.1015	0.0473
Plant height (cm)	0.4220**	1.000	0.3894**	0.3132**	0.1413	0.4610**	0.4666**	-0.2071**	0.0548	0.2130**	0.2253**	0.0036	0.1360	0.3775**	0.3361**
Number of monopodia per plant	-0.1115	0.4517**	1.000	0.2707**	0.1436	0.1097	0.2471**	0.0989	0.0193	0.2758**	0.2470**	0.2244**	-0.0520	0.1600	0.1890*
Number of sympodia per plant	0.0623	0.4299**	0.4132**	1.000	0.3263**	-0.0321	0.0039	-0.0301	0.2265**	-0.0456	0.3687**	0.0600	0.0109	0.2678**	0.3155**
Number of bolls per plant	0.0640	0.3071**	0.1571*	0.4994**	1.000	0.0038	-0.0842	0.0083	0.2107**	-0.1553*	0.4125**	-0.0650	0.1156	0.6089**	0.6213**
Boll weight	0.2432**	0.5836**	0.1469	0.0035	-0.0087	1.000	0.6172**	-0.1384	0.0838	0.5133**	-0.0292	0.0666	0.1468	0.3936**	0.3477**
Seed index	0.2017*	0.5771**	0.2671**	0.0343	-0.1215	0.6651**	1.000	-0.0865	-0.2093**	0.4415**	-0.1116	0.1412	0.0322	0.2062**	0.1149
Lint index	-0.2914**	-0.2739**	0.1296	0.0367	0.0298	-0.1729*	-0.1483	1.000	0.3239**	-0.0715	-0.0807	-0.1533	0.0437	-0.0769	0.0027
Ginning outturn	-0.0862	0.1049	0.0351	0.4236**	0.4315**	0.1491	-0.2684**	0.2438**	1.000	0.0316	0.2960**	-0.0615	0.0956	0.2589**	0.4449**
2.5% span length	0.0589	0.2564**	0.3059**	-0.0829	-0.1998*	0.5708**	0.4722**	-0.0685	0.0178	1.000	-0.0123	0.3289**	0.0046	-0.0168	-0.0207
Micronaire value (10-6 g/in)	-0.0083	0.3262**	0.3144**	0.6160**	0.6290**	-0.0369	-0.1391	-0.1911	0.3986**	-0.0302	1.000	-0.0472	-0.0143	0.3542**	0.4067**
Bundle strength	0.1030	0.0026	0.2936**	0.1214	-0.0630	0.0792	0.1667*	-0.1854*	-0.1471	0.4129**	0.0128	1.000	0.0264	-0.0706	-0.0524
Uniformity ratio	0.1676**	0.1775**	-0.0940	-0.1493	0.1586*	0.2557**	0.0257	-0.0521	0.1022	-0.0332	-0.0397	0.1294	1.000	0.1114	0.1186
Seed cotton yield per plant	0.1538	0.5328**	0.2008*	0.3855**	0.9570**	0.4762**	0.2188**	-0.2137**	0.3612**	-0.0080	0.4441**	-0.1051	0.3429**	1.000	0.9742**
Lint yield per plant (g)	0.0753	0.4701**	0.2343**	0.4575**	0.9755**	0.4171**	0.1090	-0.1376	0.5105**	-0.0173	0.5112**	-0.0884	0.3260**	0.9687**	1.000

* Significant at 5% level ** Significant at 1% level

Table 4.4. Direct and indirect effects (phenotypic) of 15 characters on seed cotton yield in intra-specific hybrids of cotton (*Gossypium hirsutum* L.) during *kharif*, 2013-14

Character	Days to 50% flowering	Plant height	Number of monopodia per plant	Number of sympodia per plant	Number of bolls per plant	Boll weight	Seed index	Lint index	Ginning outturn	2.5% span-length	Micronaire value	Bundle strength	Uniformity ratio	Lint yield per plant
Days to 50% flowering	0.0226	0.0072	-0.0028	0.0007	0.0009	0.0046	0.0039	-0.0051	-0.0010	0.0013	-0.0011	0.0021	0.0019	0.0011
Plant height	0.0098	0.0306	0.0119	0.0096	0.0043	0.0141	0.0143	-0.0063	0.0017	0.0065	0.0069	0.0001	0.0042	0.0103
Number of monopodia per plant	0.0056	-0.0175	-0.0449	-0.0121	-0.0064	-0.0049	-0.0111	-0.0044	-0.0009	-0.0124	-0.0111	-0.0101	0.0023	-0.0085
Number of sympodia per plant	-0.0005	-0.0048	-0.0041	-0.0153	-0.0050	0.0005	-0.0001	0.0005	-0.0035	0.0007	-0.0057	-0.0009	-0.0002	-0.0048
Number of bolls per plant	0.0005	0.0016	0.0017	0.0038	0.0116	0.0000	-0.0010	0.0001	0.0024	-0.0018	0.0048	-0.0008	0.0013	0.0072
Boll weight	0.0028	0.0063	0.0015	-0.0004	0.0001	0.0137	0.0084	-0.0019	0.0011	0.0070	-0.0004	0.0009	0.0020	0.0048
Seed index	0.0054	0.0146	0.0077	0.0001	-0.0026	0.0193	0.0313	-0.0027	-0.0065	0.0138	-0.0035	0.0044	0.0010	0.0036
Lint index	-0.0003	-0.0003	0.0001	0.0000	0.0000	-0.0002	-0.0001	0.0015	0.0005	-0.0001	-0.0001	-0.0002	0.0001	0.0000
Ginning outturn	0.0088	-0.0110	-0.0039	-0.0453	-0.0422	-0.0168	0.0419	-0.0648	-0.2001	-0.0063	-0.0592	0.0123	-0.0191	-0.0890
2.5% span length	0.0003	0.0010	0.0013	-0.0002	-0.0007	0.0025	0.0021	-0.0003	0.0002	0.0048	-0.0001	0.0016	0.0000	-0.0001
Micronaire value	0.0001	-0.0006	-0.0006	-0.0009	-0.0010	0.0001	0.0003	0.0002	-0.0007	0.0000	-0.0025	0.0001	0.0000	-0.0010
Bundle strength	-0.0024	-0.0001	-0.0057	-0.0015	0.0016	-0.0017	-0.0036	0.0039	0.0016	-0.0083	0.0012	-0.0253	-0.0007	0.0013
Uniformity ratio	-0.0005	-0.0007	0.0003	-0.0001	-0.0006	-0.0008	-0.0002	-0.0002	-0.0005	0.0000	0.0001	-0.0001	-0.0054	-0.0006
Lint yield per plant	0.0494	0.3510	0.1974	0.3295	0.6490	0.3632	0.1200	0.0028	0.4647	-0.0216	0.4248	-0.0548	0.1239	1.0445
Correlation with seed cotton yield per plant	0.1015	0.3775**	0.1600	0.2678**	0.6089**	0.3936**	0.2062**	-0.0769	0.2589**	-0.0165	0.3542**	-0.0706	0.1114	0.9687**

* Significant at 5% level, ** Significant at 1% level, Residual effect = 0.1357, Bold and diagonal values indicate direct effects

Table 4.5. Direct and indirect effects (genotypic) of 15 characters on seed cotton yield in intra-specific hybrids of cotton (*Gossypium hirsutum* L.) during *kharif*, 2013-14

Character	Days to 50% flowering	Plant height	Number of monopodia per plant	Number of sympodia per plant	Number of bolls per plant	Boll weight	Seed index	Lint index	Ginning outturn	2.5% span length	Micronaire value	Bundle strength	Uniformity ratio	Lint yield per plant
Days to 50% flowering	0.0273	0.0115	-0.0030	0.0017	0.0017	0.0066	0.0055	-0.0079	-0.0023	0.0016	-0.0002	0.0028	0.0046	0.0021
Plant height (cm)	0.0349	0.0828	0.0374	0.0356	0.0254	0.0483	0.0478	-0.0227	0.0087	0.0212	0.0270	0.0002	0.0147	0.0389
Number of monopodia per plant	0.0081	-0.0327	-0.0724	-0.0299	-0.0114	-0.0106	-0.0194	-0.0094	-0.0025	-0.0222	-0.0228	-0.0213	0.0068	-0.0170
Number of sympodia per plant	-0.0026	-0.0177	-0.0170	-0.0412	-0.0206	-0.0001	-0.0014	-0.0015	-0.0174	0.0034	-0.0254	-0.0050	0.0061	-0.0188
Number of bolls per plant	-0.0030	-0.0142	-0.0073	-0.0231	-0.0462	0.0004	0.0056	-0.0014	-0.0199	0.0092	-0.0291	0.0029	-0.0073	-0.0451
Boll weight	-0.0055	-0.0132	-0.0033	-0.0001	0.0002	-0.0225	-0.0150	0.0039	-0.0034	-0.0129	0.0008	-0.0018	-0.0058	-0.0094
Seed index	0.0068	0.0194	0.0090	0.0012	-0.0041	0.0224	0.0337	-0.0050	-0.0090	0.0159	-0.0047	0.0056	0.0009	0.0037
Lint index	-0.0061	-0.0058	0.0027	0.0008	0.0006	-0.0036	-0.0031	0.0210	0.0051	-0.0014	-0.0040	-0.0039	-0.0011	-0.0029
Ginning outturn	0.0142	-0.0173	-0.0058	-0.0700	-0.0713	-0.0246	0.0443	-0.0403	-0.1652	-0.0029	-0.0658	0.0243	-0.0169	-0.0843
2.5% span length	0.0001	0.0006	0.0007	-0.0002	-0.0004	0.0012	0.0010	-0.0001	0.0000	0.0022	-0.0001	0.0009	-0.0001	0.0000
Micronaire value	0.0000	-0.0007	-0.0007	-0.0013	-0.0014	0.0001	0.0003	0.0004	-0.0009	0.0001	-0.0022	0.0000	0.0001	-0.0011
Bundle strength	-0.0009	0.0000	-0.0025	-0.0010	0.0005	-0.0007	-0.0014	0.0016	0.0013	-0.0035	-0.0001	-0.0086	-0.0011	0.0008
Uniformity ratio	-0.0036	-0.0038	0.0020	0.0032	-0.0034	-0.0054	-0.0005	0.0011	-0.0022	0.0007	0.0008	-0.0028	-0.0213	-0.0069
Lint yield per plant	0.0839	0.5239	0.2611	0.5099	1.0871	0.4649	0.1215	-0.1534	0.5689	-0.0193	0.5697	-0.0985	0.3632	1.1144
Correlation with seed cotton yield per plant	0.1538	0.5328**	0.2008*	0.3855**	0.9570**	0.4762**	0.2188**	-0.2137**	0.3612**	-0.0080	0.4441**	-0.1051	0.3429**	0.9742**

* = Significant at 5% level, ** = Significant at 1% level, Residual effect = 0.1245, Bold and diagonal values indicate direct effect

Table 4. 6. Analysis of variance for combining ability for yield and its components in intra-specific hybrids of cotton (*Gossypium hirsutum* L.) during *kharif*, 2013-14

Source of variation	d.f.	Days to 50 % flowering	Plant height (cm)	Number of monopodia per plant	Number of sympodia per plant	Number of bolls per plant	Boll weight (g)	Seed index (g)	Lint index (g)
Mean sum of squares									
Replicates	2	0.95	78.96	0.06	3.96	24.51	0.02	0.03	0.11
Genotypes	52	46.38**	541.92**	1.13**	9.20**	148.13**	0.79**	24.00**	0.78**
Parents	12	22.31**	202.41**	1.19**	6.58**	72.14*	0.75**	0.75	1.05**
Parents vs crosses	1	130.28**	10255.75**	3.71**	2.67	17.53	19.27**	1137.81**	3.35**
Crosses	39	51.63**	397.32**	1.05**	10.17**	174.86**	0.32**	2.60**	0.62**
Line effect	7	26.36	874.86**	2.04**	25.23**	340.57	0.75**	6.59**	0.79
Tester effect	4	224.80**	1697.11**	4.85**	11.33	55.99	0.48	3.14	0.88
Line x tester effect	28	33.21**	92.25*	0.26**	6.24**	150.41**	0.19**	1.52**	0.55**
Error	104	4.07	51.42	0.05	1.97	35.77	0.03	0.49	0.12

Source of variation	d.f.	Ginning outturn (%)	2.5% span length (mm)	Micronaire value (10^{-6} g/inch)	Bundle strength (g/tex)	Uniformity ratio	Seed cotton yield per plant (g)	Lint yield per plant (g)
Mean sum of squares								
Replicates	2	0.44	0.27	0.01	0.48	2.50	554.32	84.04
Genotypes	52	4.46**	7.85**	0.26**	1.55**	2.70**	4388.91**	608.12**
Parents	12	1.27	11.15**	0.25**	2.92**	2.92**	724.42	128.24
Parents vs crosses	1	3.81*	76.59**	0.00	0.95*	1.43	23609.69**	1628.47**
Crosses	39	5.46**	5.08**	0.27**	1.15**	2.67**	5023.60**	729.61**
Line effect	7	9.14	8.23	1.33**	3.93**	2.72	8833.16	1399.29
Tester effect	4	1.46	4.25	0.01	0.15	6.16*	2915.61	359.11
Line x tester effect	28	5.12**	4.41**	0.05	0.59**	2.16**	4372.35**	615.12**
Error	104	0.96	0.23	0.04	0.17	0.96	584.31	73.11

*, ** Significant at 5% and 1% level, respective

Table 4.7. Estimates of general combining ability (*gca*) effects of parents for 15 traits in cotton (*Gossypium hirsutum* L.) during *kharif*, 2013-14

S.No	Parents	Days to 50% flowering	Plant height (cm)	Number of monopodia per plant	Number of sympodia per plant	Number of bolls per plant	Boll weight (g)	Seed index (g)
Lines								
1	L 762	-0.55	3.53	0.57**	1.33**	4.70**	-0.26**	-0.71**
2	L 804	-0.68	-7.85**	-0.01	1.77**	2.63	-0.15**	-0.01
3	NDLH 1938	0.98	9.25**	0.56**	1.09**	5.43**	0.09*	-0.15
4	L 1057	-0.42	6.90**	-0.19**	0.13	-2.50	0.35**	-0.69**
5	L 1060	2.78**	3.01	-0.16**	-0.43	2.83	-0.01	0.41*
6	49 JRP	-1.55**	-13.83**	-0.38**	-1.80**	-8.10**	-0.09*	1.18**
7	L 788	-0.08	-0.30	-0.28**	-1.16**	-0.50	0.27**	-0.52**
8	L 801	-0.48	-0.73	-0.10	-0.92*	-4.50**	-0.20**	0.49**
	SE (gi)	0.52	1.85	0.06	0.36	1.54	0.04	0.18
Testers								
1	CNH 50	-0.78	4.33**	-0.03	0.76**	-1.64	-0.18**	0.18
2	GISV 272	-3.28**	-13.57**	-0.10**	-0.82**	-0.47	0.01	-0.10
3	CNH 44	-0.70	-1.36	0.40**	-0.64	-1.06	-0.08*	0.42**
4	BS 47	5.05**	2.00	-0.68**	0.33	1.94	0.07	-0.55**
5	BS 49	-0.28	8.60**	0.41**	0.36	1.23	0.19**	0.05
	SE (gj)	0.41	1.46	0.45	0.29	1.22	0.03	0.14

Table 4.7 (cont..)

S.No.	Parents	Lint index (g)	Ginning outturn (%)	2.5% span length (mm)	Micronaire value (10 ⁻⁶ g/inch)	Bundle strength (g/tex)	Uniformity ratio	Seed cotton yield per plant (g)	Lint yield per plant (g)
Lines									
1	L 762	-0.32 ^{**}	0.20	-0.72 ^{**}	0.43 ^{**}	0.11	-0.33	8.95	5.28 [*]
2	L 804	0.20 [*]	0.80 ^{**}	0.49 ^{**}	0.13 [*]	0.59 ^{**}	0.27	11.88	5.80 [*]
3	NDLH 1938	-0.10	-1.12	0.28 [*]	0.09	-0.01	0.07	36.88 ^{**}	12.31 ^{**}
4	L 1057	-0.13	1.00 ^{**}	0.03	-0.08	-0.80 ^{**}	0.47	4.75	3.86
5	L 1060	0.26 ^{**}	0.20	-0.80 ^{**}	0.03	-0.61 ^{**}	-0.07	2.82	-0.26
6	49 JRP	0.26 ^{**}	-1.40 ^{**}	-0.97 ^{**}	-0.59 ^{**}	-0.03	-0.87 ^{**}	-31.52 ^{**}	-14.00 ^{**}
7	L 788	-0.24 ^{**}	0.10	0.83 ^{**}	0.16 ^{**}	0.68 ^{**}	0.27	5.22	1.99
8	L 801	0.08	-0.78 ^{**}	0.85 ^{**}	-0.17 ^{**}	0.08	0.20	-38.78 ^{**}	-15.00 ^{**}
	SE (gi)	0.09	0.25	0.12	0.05	0.10	0.25	6.24	2.20
Testers									
1	CNH 50	0.01	-0.28	-0.25 [*]	0.01	0.10	-0.20	-11.82 [*]	-4.52 [*]
2	GISV 272	0.02	0.23	0.17	-0.002	-0.08	-0.10	-6.32	-0.65
3	CNH 44	0.20 ^{**}	-0.16	0.55 ^{**}	0.02	-0.004	-0.57 ^{**}	-5.37	-2.55
4	BS 47	-0.32 ^{**}	-0.08	0.32 ^{**}	0.01	-0.07	0.06	11.13 [*]	2.68
5	BS 49	0.09	0.29	-0.46 ^{**}	-0.03	0.05	0.81 ^{**}	12.38 [*]	5.03 ^{**}
	SE (gj)	0.07	0.20	0.10	0.04	0.08	0.20	4.93	1.74

* Significant at 5% level

** Significant at 1% level

Table 4.8. Estimates of specific combining ability (*sca*) effects for days to 50% flowering, plant height (cm), number of monopodia per plant and number of sympodia per plant in intra-specific hybrids of cotton (*Gossypium hirsutum* L.) during *kharif*, 2013-14

S.No.	Crosses	Days to 50% flowering	Plant height (cm)	Number of monopodia per plant	Number of sympodia per plant
1	L 762 × CNH 50	0.05	10.12*	0.48**	1.50
2	L 762 × GISV 272	0.55	4.56	0.18	1.78*
3	L 762 × CNH 44	2.63*	-0.85	-0.03	-1.90*
4	L 762 × BS 47	0.88	-7.04	-0.04	-0.50
5	L 762 × BS 49	-4.12**	-6.79	-0.60**	-0.87
6	L 804 × CNH 50	-3.82**	-6.72	-0.01	-0.91
7	L 804 × GISV 272	-0.32	0.08	0.19	-0.80
8	L 804 × CNH 44	1.10	6.87	0.26*	0.12
9	L 804 × BS 47	-0.65	1.11	-0.32*	1.15
10	L 804 × BS 49	3.68**	-1.34	-0.12	0.45
11	NDLH 1938 × CNH 50	-1.48	1.84	0.23	1.74*
12	NDLH 1938 × GISV 272	-2.65*	-2.00	0.09	-0.35
13	NDLH 1938 × CNH 44	7.43**	-6.80	-0.11	-1.83*
14	NDLH 1938 × BS 47	-2.65*	1.84	-0.22	2.27**
15	NDLH 1938 × BS 49	-0.65	5.13	0.02	-1.83*
16	L 1057 × CNH 50	0.58	3.62	-0.12	-0.74
17	L 1057 × GISV 272	1.75	1.26	-0.42**	-0.16
18	L 1057 × CNH 44	-1.50	-3.65	0.31*	2.22**
19	L 1057 × BS 47	-0.58	-1.81	0.16	-2.98**
20	L 1057 × BS 49	-0.25	0.58	0.07	1.66*
21	L 1060 × CNH 50	1.05	-5.92	0.29*	-0.41
22	L 1060 × GISV 272	2.55*	0.84	-0.08	-0.63
23	L 1060 × CNH 44	3.30**	-4.23	0.05	-0.31
24	L 1060 × BS 47	-0.12	4.08	-0.40**	1.26
25	L 1060 × BS 49	-6.78**	5.23	0.14	0.09
26	49 JRP × CNH 50	0.38	-2.42	-0.06	-1.47
27	49 JRP × GISV 272	-1.45	-7.62	-0.16	0.08
28	49 JRP × CNH 44	-5.70**	5.91	-0.37**	1.46
29	49 JRP × BS 47	3.55**	9.92*	0.29*	-1.04
30	49 JRP × BS 49	3.22**	-5.80	0.30*	0.96
31	L 788 × CNH 50	1.25	1.79	-0.39**	-0.47
32	L 788 × GISV 272	0.75	2.29	0.04	0.34
33	L 788 × CNH 44	-5.50**	-2.38	-0.13	0.96
34	L 788 × BS 47	0.08	-1.48	0.29*	0.32
35	L 788 × BS 49	3.42**	-0.22	0.20	-1.14
36	L 801 × CNH 50	1.98	-2.32	-0.41**	0.75
37	L 801 × GISV 272	-1.18	0.58	0.16	-0.24
38	L 801 × CNH 44	-1.77	5.14	0.02	-0.72
39	L 801 × BS 47	-0.52	-6.62	0.24	-0.48
40	L 801 × BS 49	1.48	3.20	-0.02	0.68
	SE (<i>s_{ij}</i>)	1.16	4.14	0.13	0.81

* Significant at 5% level ** Significant at 1% level

Table 4.9. Estimates of specific combining ability (*sca*) effects for number of bolls per plant, boll weight (g), seed index (g) and lint index (g) in intra-specific hybrids of cotton (*Gossypium hirsutum* L.) during *kharif*, 2013-14

S.No.	Crosses	Number of bolls per plant	Boll weight (g)	Seed index (g)	Lint index (g)
1	L 762 × CNH 50	-2.16	-0.16	0.05	0.21
2	L 762 × GISV 272	7.68*	0.11	0.99*	0.63**
3	L 762 × CNH 44	-5.07	0.10	0.20	-0.22
4	L 762 × BS 47	-11.41**	0.12	-0.79	-0.42*
5	L 762 × BS 49	10.97**	-0.17	-0.45	-0.19
6	L 804 × CNH 50	6.57	-0.11	0.01	-0.10
7	L 804 × GISV 272	-5.59	0.16	0.42	0.27
8	L 804 × CNH 44	9.66**	0.06	0.06	0.17
9	L 804 × BS 47	-3.67	-0.13	0.30	-0.07
10	L 804 × BS 49	-6.97*	0.02	-0.79	-0.27
11	NDLH 1938 × CNH 50	-0.22	-0.16	1.52**	0.72**
12	NDLH 1938 × GISV 272	10.27**	0.02	-0.30	0.00
13	NDLH 1938 × CNH 44	-2.81	0.08	-0.75	-0.53**
14	NDLH 1938 × BS 47	-2.14	0.13	-0.68	-0.22
15	NDLH 1938 × BS 49	-5.10	-0.06	0.22	0.04
16	L 1057 × CNH 50	3.38	0.02	-0.41	-0.19
17	L 1057 × GISV 272	-8.79*	-0.01	-0.87*	-0.73**
18	L 1057 × CNH 44	-6.21	-0.28**	0.55	0.39
19	L 1057 × BS 47	-1.21	0.03	-0.25	0.00
20	L 1057 × BS 49	12.83**	0.25*	0.99*	0.52*
21	L 1060 × CNH 50	-5.29	0.44**	0.82*	-0.11
22	L 1060 × GISV 272	2.88	-0.48**	-0.10	-0.18
23	L 1060 × CNH 44	-3.88	-0.12	0.28	0.32
24	L 1060 × BS 47	6.13	-0.04	-0.72	0.00
25	L 1060 × BS 49	0.17	0.20*	-0.28	-0.03
26	49 JRP × CNH 50	-7.03*	-0.24*	-0.55	-0.58**
27	49 JRP × GISV 272	-1.19	-0.16	0.23	0.30
28	49 JRP × CNH 44	9.39**	0.26**	0.01	-0.16
29	49 JRP × BS 47	6.39	-0.02	0.62	0.34
30	49 JRP × BS 49	-7.57*	0.16	-0.31	0.10
31	L 788 × CNH 50	4.71	0.24*	-1.21**	-0.28
32	L 788 × GISV 272	-3.13	-0.02	-0.23	-0.68**
33	L 788 × CNH 44	-2.21	-0.43**	0.31	0.28
34	L 788 × BS 47	3.46	0.19	0.85*	0.73**
35	L 788 × BS 49	-2.83	0.03	0.29	-0.05
36	L 801 × CNH 50	0.04	-0.02	-0.22	0.34*
37	L 801 × GISV 272	-2.13	0.38**	-0.14	0.40
38	L 801 × CNH 44	1.13	0.34**	-0.66	-0.25
39	L 801 × BS 47	2.46	-0.27**	0.68	-0.38
40	L 801 × BS 49	-1.50	-0.43**	0.35	-0.11
	SE (<i>S_{ij}</i>)	3.45	0.09	0.40	0.20

* Significant at 5% level ** Significant at 1% level

Table 4.10. Estimates of specific combining ability (*sca*) effects for ginning outturn (%), 2.5% span length (mm), micronaire value (10^{-6} g/inch) and bundle strength (g/tex) in intra-specific hybrids of cotton (*Gossypium hirsutum* L.) during *kharif*, 2013-14

S.No.	Crosses	Ginning out-turn (%)	2.5% span length (mm)	Micronaire value (10^{-6} g/inch)	Bundle strength (g/tex)
1	L 762 × CNH 50	0.68	0.32	0.03	-0.05
2	L 762 × GISV 272	0.47	0.08	0.07	0.56*
3	L 762 × CNH 44	-1.41*	0.71*	-0.31**	0.16
4	L 762 × BS 47	-0.09	0.43	0.03	0.23
5	L 762 × BS 49	0.35	-1.55**	0.17	-0.90**
6	L 804 × CNH 50	-0.45	0.24	0.04	-0.21
7	L 804 × GISV 272	0.21	-1.40**	-0.08	0.13
8	L 804 × CNH 44	0.53	0.33	0.13	0.32
9	L 804 × BS 47	-0.95	-0.08	0.01	-0.10
10	L 804 × BS 49	0.65	0.91**	-0.09	-0.13
11	NDLH 1938 × CNH 50	-0.37	0.02	0.01	0.51*
12	NDLH 1938 × GISV 272	0.79	1.52**	0.05	-0.91**
13	NDLH 1938 × CNH 44	-0.62	-0.35	-0.07	0.58*
14	NDLH 1938 × BS 47	0.56	-1.94**	0.05	-0.58*
15	NDLH 1938 × BS 49	-0.37	0.75**	-0.05	0.39
16	L 1057 × CNH 50	0.13	1.00**	0.05	0.07
17	L 1057 × GISV 272	-1.05	0.50	0.05	-0.13
18	L 1057 × CNH 44	0.37	0.16	-0.07	0.27
19	L 1057 × BS 47	0.66	1.24**	-0.12	0.14
20	L 1057 × BS 49	-0.11	-2.90**	0.08	-0.35
21	L 1060 × CNH 50	-2.05**	0.47	-0.03	-0.12
22	L 1060 × GISV 272	-0.56	-0.57*	0.01	0.22
23	L 1060 × CNH 44	0.66	0.96**	-0.05	-0.12
24	L 1060 × BS 47	1.58**	-0.76**	0.07	-0.11
25	L 1060 × BS 49	0.38	-0.10	0.00	0.13
26	49 JRP × CNH 50	-1.29*	-1.53**	-0.01	0.23
27	49 JRP × GISV 272	0.73	0.70*	-0.07	0.00
28	49 JRP × CNH 44	-0.55	-0.61*	0.17	-1.00**
29	49 JRP × BS 47	0.07	-0.99**	-0.08	0.33
30	49 JRP × BS 49	1.04	2.43**	-0.01	0.44
31	L 788 × CNH 50	1.59**	-0.17	-0.13	-0.05
32	L 788 × GISV 272	-2.52**	-0.27	0.12	-0.11
33	L 788 × CNH 44	0.53	-1.27**	0.09	-0.11
34	L 788 × BS 47	1.18*	1.51**	0.14	0.26
35	L 788 × BS 49	-0.78	0.20	-0.22	0.00
36	L 801 × CNH 50	1.77**	-0.35	0.04	-0.38
37	L 801 × GISV 272	1.93**	-0.56*	-0.15	0.23
38	L 801 × CNH 44	0.48	0.07	0.09	-0.11
39	L 801 × BS 47	-3.00**	0.59*	-0.09	-0.17
40	L 801 × BS 49	-1.17*	0.25	0.11	0.43
	SE (<i>s_{ij}</i>)	0.56	0.28	0.12	0.24

* Significant at 5% level ** Significant at 1% level

Table 4.11. Estimates of specific combining ability (sca) effects for uniformity ratio, seed cotton yield per plant (g) and lint yield per plant (g) in intra-specific hybrids of cotton (*Gossypium hirsutum* L.) during kharif , 2013-14

S.No.	Crosses	Uniformity ratio	Seed cotton yield per plant (g)	Lint yield per plant (g)
1	L 762 × CNH 50	-0.54	-30.24*	-10.97*
2	L 762 × GISV 272	0.38	33.92*	19.22**
3	L 762 × CNH 44	0.83	-6.37	-7.21
4	L 762 × BS 47	-1.13*	-38.20**	-14.29**
5	L 762 × BS 49	0.46	40.88**	13.25**
6	L 804 × CNH 50	-1.14*	26.83	7.84
7	L 804 × GISV 272	0.44	-13.68	-5.44
8	L 804 × CNH 44	0.23	41.03**	16.26**
9	L 804 × BS 47	0.61	-21.47	-8.72
10	L 804 × BS 49	-0.14	-32.72*	-9.94*
11	NDLH 1938 × CNH 50	-0.27	-28.31*	-10.86*
12	NDLH 1938 × GISV 272	-0.03	51.53**	19.07**
13	NDLH 1938 × CNH 44	0.43	-4.43	-2.91
14	NDLH 1938 × BS 47	-1.19*	4.07	3.89
15	NDLH 1938 × BS 49	1.06	-22.85	-9.19
16	L 1057 × CNH 50	-0.34	24.29	8.51
17	L 1057 × GISV 272	0.58	-41.54**	-18.00**
18	L 1057 × CNH 44	-0.63	-48.17**	-16.03**
19	L 1057 × BS 47	0.41	-14.00	-2.56
20	L 1057 × BS 49	-0.01	79.42**	28.07**
21	L 1060 × CNH 50	1.19*	-8.44	-6.17
22	L 1060 × GISV 272	-0.89	-10.27	-4.24
23	L 1060 × CNH 44	-0.10	-25.57	-5.58
24	L 1060 × BS 47	-0.39	42.93**	13.05**
25	L 1060 × BS 49	0.19	1.35	2.93
26	49 JRP × CNH 50	-0.34	-40.11**	-14.96**
27	49 JRP × GISV 272	-1.09	-29.94*	-9.71
28	49 JRP × CNH 44	-0.30	59.10**	18.57**
29	49 JRP × BS 47	1.74**	39.93**	14.02**
30	49 JRP × BS 49	-0.01	-28.98*	-7.92
31	L 788 × CNH 50	0.52	48.49**	20.74**
32	L 788 × GISV 272	-0.23	-7.01	-9.44
33	L 788 × CNH 44	0.57	-32.97*	-10.09*
34	L 788 × BS 47	-0.39	2.20	4.70
35	L 788 × BS 49	-0.47	-10.72	-5.91
36	L 801 × CNH 50	0.92	7.49	5.86
37	L 801 × GISV 272	0.84	16.99	8.54
38	L 801 × CNH 44	-1.03	17.37	6.99
39	L 801 × BS 47	0.34	-15.47	-10.08*
40	L 801 × BS 49	-1.08	-26.38	-11.30*
	SE (s _{ij})	0.56	13.95	4.93

* Significant at 5% level ** Significant at 1% level

Table 4.12. Estimates of genetic components of variance and proportional contribution of lines, testers and line x tester interaction to total variance for 15 traits in cotton (*Gossypium hirsutum* L.) during *kharif*, 2013-14

S.No.		Days to 50% flowering	Plant height (cm)	Number of monopodia per plant	Number of sympodia per plant	Number of bolls per plant	Boll weight (g)	Seed index (g)	Lint index (g)
1	GCA	4.737**	61.217**	0.163**	0.617**	2.455*	0.022**	0.171**	0.015**
2	SCA	9.716**	13.609*	0.071**	1.424**	38.215**	0.055**	0.345**	0.143**
3	GCA/SCA	0.488	4.498	2.296	0.433	0.064	0.400	0.496	0.105
Contribution (%)									
4	Lines	9.162	39.521	34.819	44.531	34.959	41.698	45.531	22.720
5	Testers	44.654	43.810	47.363	11.425	3.284	15.260	12.412	14.504
6	Line x Tester	46.184	16.669	17.818	44.043	61.757	43.042	42.058	62.776

S.No.		Ginning outturn (%)	2.5% span length (mm)	Micronaire value (10 ⁻⁶ g/inch)	Bundle strength (g/tex)	Uniformity ratio	Seed cotton yield per plant (g)	Lint yield per plant (g)
1	GCA	0.010	0.094*	0.032**	0.074**	0.117**	77.027*	13.543*
2	SCA	1.386**	1.392**	0.001	0.140**	0.401**	1262.679**	180.671**
3	GCA/SCA	0.007	0.068	32.000	0.529	0.292	0.061	0.075
Contribution (%)								
4	Lines	30.033	29.073	87.702	61.498	18.310	31.560	34.423
5	Testers	2.746	8.577	0.320	1.298	23.656	5.953	5.048
6	Line x Tester	67.221	62.350	11.979	37.204	58.035	62.487	60.529

* Significant at 5% level

** Significant at 1% level

Table 4.13. Gene actions for seed cotton yield and component characters in intra-specific hybrids of cotton (*Gossypium hirsutum* L.) during *kharif*, 2013-14

S. No.	Character	GCA/SCA	Type of Gene Action
1	Days to 50 % flowering	0.488	Non-Additive
2	Plant height (cm)	4.498	Additive
3	Number of monopodia per plant	2.296	Additive
4	Number of sympodia per plant	0.433	Non-Additive
5	Number of bolls per plant	0.064	Non-Additive
6	Boll weight (g)	0.400	Non-Additive
7	Seed index (g)	0.496	Non-Additive
8	Lint index (g)	0.105	Non-Additive
9	Ginning outturn (%)	0.007	Non-Additive
10	2.5% span length (mm)	0.068	Non-Additive
11	Micronaire value (10^{-6} g/inch)	32.000	Additive
12	Bundle strength (g/tex)	0.529	Non-Additive
13	Uniformity ratio	0.292	Non-Additive
14	Seed cotton yield per plant (g)	0.061	Non-Additive
15	Lint yield per plant (g)	0.075	Non-Additive

Table 4.14. Good general combiners of lines and testers for 15 traits in cotton (*Gossypium hirsutum* L.) during *kharif*, 2013-14

S. No.	Characters	Lines								Testers				
		L 762	L 804	NDLH 1938	L 1057	L 1060	49 JRP	L 788	L 801	CNH 50	GISV 272	CNH 44	BS 47	BS 49
1.	Days to 50% flowering					+			+				+	
2.	Plant height (cm)			+	+					+				+
3.	Number of monopodia per plant	+		+								+		+
4.	Number of sympodia per plant	+	+	+										
5.	Number of bolls per plant	+		+										
6.	Boll weight (g)			+	+			+						+
7.	Seed index(g)					+	+		+			+		
8.	Lint index (g)					+	+					+		
9.	Ginning outturn (%)		+		+									
10.	2.5% span length (mm)		+	+				+	+			+	+	
11.	Micronaire value (10 ⁻⁶ g/inch)	+	+					+		+			+	
12.	Bundle strength (g/tex)		+					+						
13.	Uniformity ratio													+
14.	Seed cotton yield per plant (g)			+									+	+
15.	Lint yield per plant (g)	+	+	+					+	+				+

+ - indicates good general combiner

Table 4.15. Estimates of heterosis over mid parent (MP), better parent (BP) and standard check (SH) for days to 50% flowering, plant height (cm), number of monopodia per plant and number of sympodia per plant in intra-specific cotton hybrids (*Gossypium hirsutum* L.) during *kharif*, 2013-14

S.No.		Days to 50% flowering			Plant height (cm)			Number of monopodia per plant			Number of sympodia per plant		
		MP	BP	SH	MP	BP	SH	MP	BP	SH	MP	BP	SH
1	L 762 × CNH 50	-2.16	-2.16	5.23	22.97**	18.50**	29.56**	92.77**	17.65*	37.93**	20.04**	7.04	18.44**
2	L 762 × GISV 272	-1.41	-5.41*	1.74	10.45*	0.23	9.59	79.22**	1.47	18.97*	9.36	0.34	11.03
3	L 762 × CNH 44	4.13	2.16	9.88**	11.39**	5.53	15.38**	45.79*	14.71	34.48**	-6.17	-17.70**	-8.94
4	L 762 × BS 47	6.35**	4.15	16.86**	10.84*	3.32	12.96*	8.43	-33.82**	-22.41*	0.55	-5.50	4.56
5	L 762 × BS 49	-7.36**	-8.11**	-1.16	13.74**	8.67	18.81**	-3.17	-10.29	5.17	-3.74	-7.22	2.66
6	L 804 × CNH 50	-3.43	-8.65**	-1.74	8.45	4.09	5.53	74.55**	20.00	-17.24	16.29**	9.73	7.22
7	L 804 × GISV 272	2.69	1.18	0.00	5.40	3.07	-3.91	112.24**	30.00*	-10.34	4.00	1.17	-1.14
8	L 804 × CNH 44	7.29**	3.37	6.98	17.52**	14.76**	12.26*	74.68**	72.50**	18.97*	16.05*	7.59	5.13
9	L 804 × BS 47	9.50**	1.55	13.95**	17.42**	16.63**	10.21*	-30.91	-52.50**	-67.24**	19.49**	19.26**	16.54**
10	L 804 × BS 49	11.24	6.04*	12.21**	18.01**	14.25**	13.76**	18.37	0.00	0.00	12.52*	9.81	12.74
11	NDLH 1938 × CNH 50	-0.55**	-2.16	5.23	22.61**	19.73**	27.38**	73.49**	5.88	24.14*	20.50**	7.79	18.44**
12	NDLH 1938 × GISV 272	-2.58	-5.03	-1.16	11.39*	2.35	8.88	71.43**	-2.94	13.79	-3.57	-11.25	-2.47
13	NDLH 1938 × CNH 44	16.53**	16.20**	20.93**	12.81**	8.27	15.18**	40.19**	10.29	29.31**	-6.78	-17.99**	-9.89
14	NDLH 1938 × BS 47	4.84*	1.04	13.37**	24.84**	17.87**	25.39**	-6.02	-42.65**	-32.76**	14.86**	8.30	19.01**
15	NDLH 1938 × BS 49	2.49	1.65	7.56*	29.94**	25.79**	33.82**	25.40**	16.18*	36.21**	-9.84	-12.80*	-4.18
16	L 1057 × CNH 50	0.00	-1.08	6.40*	23.36**	21.62**	26.89**	27.87	-15.22	-32.76**	3.90	-4.59	-1.14
17	L 1057 × GISV 272	1.99	-1.10	4.07	13.36**	5.08	9.65	1.82	-39.13**	-51.72**	-4.95	-10.09	-6.84
18	L 1057 × CNH 44	-1.39	-2.21	2.91	14.62**	11.04*	15.86**	52.94**	41.30	12.07	15.24*	4.04	7.79
19	L 1057 × BS 47	5.35*	2.07	14.53**	20.99**	15.28**	20.28**	-8.20	-39.13	-51.72**	-16.75**	-19.27**	-16.35*
20	L 1057 × BS 49	0.28	0.00	5.81*	25.49**	22.62**	27.94**	11.54	0.00	0.00	6.91	6.42	10.27
21	L 1060 × CNH 50	4.02	3.19	12.79**	17.49**	13.88**	15.46**	96.23**	36.84*	-10.34	8.00	3.85	-2.47
22	L 1060 × GISV 272	6.70**	1.60	11.05**	15.04**	11.39**	5.99	65.96**	2.63	-32.76**	-6.33	-7.09	-12.74
23	L 1060 × CNH 44	9.84**	6.91*	16.86**	16.14**	14.56**	12.06*	50.65**	48.72*	0.00	1.61	-4.05	-9.89
24	L 1060 × BS 47	9.19**	7.77**	20.93**	28.65**	28.21**	21.99**	-54.72**	-68.42**	-79.31**	9.34	7.42	4.56
25	L 1060 × BS 49	-7.03**	-8.51**	0.00	32.08**	29.15**	28.60**	27.08**	5.17	5.17	-0.19	-4.44	-1.90
26	49 JRP × CNH 50	0.28	-3.24	4.07	12.06	2.69	4.11	62.79**	25.00	-39.66**	-4.97	-6.38	-16.35*

Table 4.15 (cont.)

		Days to 50% flowering			Plant height (cm)			Number of monopodia per plant			Number of sympodia per plant		
		MP	BP	SH	MP	BP	SH	MP	BP	SH	MP	BP	SH
27	49 JRP× GISV 272	-2.92	-3.49	-3.49	-2.66	-5.22	-15.55**	62.16*	7.14	-48.28**	-8.16	-9.67	-16.54*
28	49 JRP× CNH 44	-8.00**	-9.55**	-6.40**	16.72**	8.73	6.35	16.42	0.00	-32.76**	6.93	3.40	-7.60
29	49 JRP× BS 47	12.88**	6.74*	19.77**	25.89**	19.18**	12.62*	20.93	-7.14	-55.17**	-10.39	-14.06*	-16.35*
30	49 JRP× BS 49	6.78**	3.85	9.88**	14.00**	5.33	4.88	37.21**	1.72	1.72	-0.79	-7.22	-4.75
31	L 788× CNH 50	4.79	0.54	8.14**	17.60**	17.57**	19.21**	1.82	-30.00*	-51.72**	4.71	2.30	-7.03
32	L 788× GISV 272	4.12	4.12	2.91	9.64*	3.02	4.40	59.18**	-2.50	-32.76**	-3.32	-4.12	-11.41
33	L 788× CNH 44	-4.60	-6.74*	-3.49	11.28*	9.35	10.81*	24.05*	22.50	-15.52	6.87	2.51	-6.84
34	L 788× BS 47	10.19**	3.63	16.28**	16.88**	12.93*	14.44**	5.45	-27.50*	-50.00**	1.01	-2.34	-4.94
35	L 788× BS 49	10.23**	6.59*	12.79**	20.59**	19.54**	21.13**	20.41*	1.72	1.72	-10.22	-15.37*	-13.12*
36	L 801× CNH 50	4.47	1.08	8.72**	13.32**	12.88**	15.35**	22.22	-15.38	-43.10**	12.92*	9.22	1.33
37	L 801× GISV 272	-0.87	-1.73	-1.16	7.25	0.39	2.58	100.00**	23.08	-17.24	-6.37	-6.56	-13.31*
38	L 801× CNH 44	0.28	-1.12	2.33	16.85**	14.35**	16.85**	51.28**	51.28**	1.72	-3.56	-8.40	-15.02*
39	L 801× BS 47	7.65**	2.07	14.53**	11.55*	7.36	9.70	22.22	-15.38	-43.10**	-3.40	-5.66	-8.17
40	L 801× BS 49	5.35**	2.75	8.72**	22.61**	21.04**	23.69**	19.59*	0.00	0.00	0.97	-3.89	-1.33
	Mean	3.18	0.50	7.47	16.46	12.13	14.25	36.83	1.34	-14.91	2.56	-2.39	-2.02
	Range	-8.00 to 16.53	-9.55 to 16.20	-6.40 to 20.93	-2.66 to 32.08	-5.22 to 29.15	-15.55 to 33.82	-54.72 to 112.24	-68.42 to 72.50	-79.31 to 37.93	-16.75 to 20.50	-19.27 to 19.26	-16.54 to 19.01

*, ** Significant at 5% and 1% level, respectively.

Table 4.16. Estimates of heterosis over mid parent (MP), better parent (BP) and standard check (SH) for number of bolls per plant, boll weight (g), seed index (g) and lint index (g) in intra-specific cotton hybrids (*Gossypium hirsutum* L.) during *kharif*, 2013-14

S.No.		Number of bolls per plant			Boll weight (g)			Seed index (g)			Lint index (g)		
		MP	BP	SH	MP	BP	SH	MP	BP	SH	MP	BP	SH
1	L 762 × CNH 50	-2.64	-11.23	-2.92	19.09 ^{**}	19.09 ^{**}	-2.96	170.00 ^{**}	170.00 ^{**}	120.00 ^{**}	-10.96 ^{**}	-14.17 ^{**}	-13.71 ^{**}
2	L 762 × GISV 272	9.64	6.42	16.37	25.54 ^{**}	19.83 ^{**}	7.41 [*]	174.46 ^{**}	161.98 ^{**}	134.81 ^{**}	0.26	-0.17	-6.88
3	L 762 × CNH 44	-10.17	-14.97	-7.02	24.02 ^{**}	19.33 ^{**}	5.19	169.87 ^{**}	159.66 ^{**}	128.89 ^{**}	-13.81 ^{**}	-15.82 ^{**}	-17.63 ^{**}
4	L 762 × BS 47	-21.16 ^{**}	-21.99 ^{**}	-12.87	20.49 ^{**}	9.70 ^{**}	8.89 ^{**}	104.92 ^{**}	86.57 ^{**}	85.19 ^{**}	-17.75 ^{**}	-24.03 ^{**}	-29.14 ^{**}
5	L 762 × BS 49	24.42 ^{**}	14.44	25.15 ^{**}	14.06 ^{**}	2.16	5.19	123.29 ^{**}	100.00 ^{**}	105.93 ^{**}	-15.82 ^{**}	-18.43 ^{**}	-18.87 ^{**}
6	L 804 × CNH 50	21.57 [*]	20.78 [*]	8.77	19.30 ^{**}	15.25 ^{**}	0.74	178.07 ^{**}	168.64 ^{**}	134.81 ^{**}	-6.30	-10.86 [*]	-10.38 [*]
7	L 804 × GISV 272	-6.71	-13.07	-10.53	25.52 ^{**}	23.97 ^{**}	11.11 ^{**}	168.62 ^{**}	165.29 ^{**}	137.78 ^{**}	4.58	3.60	-4.19
8	L 804 × CNH 44	23.51 ^{**}	17.96 [*]	15.20	21.52 ^{**}	21.01 ^{**}	6.67 [*]	175.11 ^{**}	173.95 ^{**}	141.48 ^{**}	2.85	-0.88	-3.01
9	L 804 × BS 47	-3.21	-13.09	-2.92	13.49 ^{**}	6.72 [*]	5.93	141.27 ^{**}	126.87 ^{**}	125.19 ^{**}	0.06	-6.40	-15.05 ^{**}
10	L 804 × BS 49	-0.32	-1.91	-9.94	17.51 ^{**}	8.63 ^{**}	11.85 ^{**}	124.90 ^{**}	107.91 ^{**}	114.07 ^{**}	-7.29	-11.35 [*]	-11.83 [*]
11	NDLH 1938 × CNH 50	4.50	-2.79	1.75	25.11 ^{**}	21.37 ^{**}	5.19	215.42 ^{**}	205.98 ^{**}	165.19 ^{**}	8.38	-2.46	-1.94
12	NDLH 1938 × GISV 272	17.75	16.76 [*]	22.22 ^{**}	28.57 ^{**}	26.45 ^{**}	13.33 ^{**}	147.90 ^{**}	143.80 ^{**}	118.52 ^{**}	0.12	-6.40	-13.44 ^{**}
13	NDLH 1938 × CNH 44	-2.89	-6.15	-1.75	28.81 ^{**}	27.73 ^{**}	12.59 ^{**}	151.69 ^{**}	149.58 ^{**}	120.00 ^{**}	-9.29 [*]	-17.36 ^{**}	-19.14 ^{**}
14	NDLH 1938 × BS 47	-3.24	-6.28	4.68	25.90 ^{**}	17.91 ^{**}	17.04 ^{**}	115.14 ^{**}	101.49 ^{**}	100.00 ^{**}	-2.63	-3.48	-22.37 ^{**}
15	NDLH 1938 × BS 49	0.00	-6.15	-1.75	21.87 ^{**}	12.23 ^{**}	15.56 ^{**}	146.09 ^{**}	126.62 ^{**}	133.33 ^{**}	-1.73	-11.14 [*]	-11.61 [*]
16	L 1057 × CNH 50	-2.42	-8.52	-5.85	26.02 ^{**}	13.97 ^{**}	14.81 ^{**}	130.89 ^{**}	108.82 ^{**}	110.37 ^{**}	-21.55 ^{**}	-25.33 ^{**}	-16.94 ^{**}
17	L 1057 × GISV 272	-27.27 ^{**}	-27.27 ^{**}	-25.15 ^{**}	24.51 ^{**}	17.65 ^{**}	18.52 ^{**}	103.89 ^{**}	92.65 ^{**}	94.07 ^{**}	-26.95 ^{**}	-33.11 ^{**}	-25.59 ^{**}
18	L 1057 × CNH 44	-21.87 ^{**}	-23.86 ^{**}	-21.64 [*]	16.86 ^{**}	9.56 ^{**}	10.37 ^{**}	150.98 ^{**}	135.29 ^{**}	137.04 ^{**}	-8.77 [*]	-14.26 ^{**}	-4.62
19	L 1057 × BS 47	-13.90 [*]	-17.28 [*]	-7.60	20.74 ^{**}	19.85 ^{**}	20.74 ^{**}	97.78 ^{**}	96.32 ^{**}	97.78 ^{**}	-15.00 ^{**}	-27.31 ^{**}	-19.14 ^{**}
20	L 1057 × BS 49	18.92 [*]	12.50	15.79	25.82 ^{**}	24.46 ^{**}	28.15 ^{**}	134.18 ^{**}	131.65 ^{**}	138.52 ^{**}	-9.06 [*]	-13.87 ^{**}	-4.19
21	L 1060 × CNH 50	-4.13	-6.21	-11.70	29.22 ^{**}	18.05 ^{**}	16.30 ^{**}	191.36 ^{**}	166.17 ^{**}	162.22 ^{**}	-9.41 [*]	-9.95 [*]	-9.46 [*]
22	L 1060 × GISV 272	6.23	1.70	4.68	6.30 [*]	1.50	0.00	150.39 ^{**}	139.10 ^{**}	135.56 ^{**}	-6.73	-9.96 [*]	-10.54 [*]
23	L 1060 × CNH 44	-4.27	-5.99	-8.19	13.49 ^{**}	7.52 [*]	5.93	173.81 ^{**}	159.40 ^{**}	155.56 ^{**}	1.80	1.03	0.38
24	L 1060 × BS 47	11.36	2.62	14.62	12.36 ^{**}	11.94 ^{**}	11.11 ^{**}	114.23 ^{**}	113.43 ^{**}	111.85 ^{**}	-2.35	-12.34 ^{**}	-12.90 ^{**}
25	L 1060 × BS 49	10.69	9.32	2.92	18.38 ^{**}	15.83 ^{**}	19.26 ^{**}	133.09 ^{**}	128.06 ^{**}	134.81 ^{**}	-6.22	-6.27	-6.77

Table 4.16 (cont.)

S.No.		Number of bolls per plant			Boll weight (g)			Seed index (g)			Lint index (g)		
		MP	BP	SH	MP	BP	SH	MP	BP	SH	MP	BP	SH
26	49 JRP× CNH 50	-26.14 ^{**}	-26.62 ^{**}	-33.92 ^{**}	22.94 ^{**}	21.82 ^{**}	-0.74	208.26 ^{**}	205.45 ^{**}	148.89 ^{**}	-12.27 ^{**}	-17.43 ^{**}	-16.99 ^{**}
27	49 JRP× GISV 272	-18.29 [*]	-23.86 ^{**}	-21.64 [*]	24.02 ^{**}	17.36 ^{**}	5.19	206.55 ^{**}	190.08 ^{**}	160.00 ^{**}	7.36	5.17	-2.74
28	49 JRP× CNH 44	2.82	-1.80	-4.09	33.92 ^{**}	27.73 ^{**}	12.59 ^{**}	217.18 ^{**}	202.52 ^{**}	166.67 ^{**}	-0.63	-5.27	-7.31
29	49 JRP× BS 47	-4.37	-14.14	-4.09	22.31 ^{**}	10.45 ^{**}	9.63 ^{**}	188.43 ^{**}	160.45 ^{**}	158.52 ^{**}	10.38 [*]	4.36	-7.42
30	49 JRP× BS 49	-22.33 ^{**}	-23.57 [*]	-29.82 ^{**}	27.13 ^{**}	12.95 ^{**}	16.30 ^{**}	174.49 ^{**}	143.88 ^{**}	151.11 ^{**}	1.31	-4.16	-4.68
31	L 788× CNH 50	10.68	10.32	0.00	17.34 ^{**}	-1.24	17.78 ^{**}	95.57 ^{**}	64.60 ^{**}	96.30 ^{**}	-20.75 ^{**}	-20.85 ^{**}	-20.22 ^{**}
32	L 788× GISV 272	-8.76	-14.20	-11.70	11.35 ^{**}	-2.48	16.30 ^{**}	102.84 ^{**}	77.64 ^{**}	111.85 ^{**}	-24.06 ^{**}	-27.20 ^{**}	-26.61 ^{**}
33	L 788× CNH 44	-5.59	-8.98	-11.11	1.43	-11.80 ^{**}	5.19	127.14 ^{**}	97.52 ^{**}	135.56 ^{**}	-7.66	-9.01 [*]	-8.28
34	L 788× BS 47	2.89	-6.81	4.09	11.86 ^{**}	2.48	22.22 ^{**}	106.78 ^{**}	89.44 ^{**}	125.93 ^{**}	0.93	-9.97 [*]	-9.25 [*]
35	L 788× BS 49	0.64	0.00	-8.19	9.33 ^{**}	1.86	21.48 ^{**}	104.00 ^{**}	90.06 ^{**}	126.67 ^{**}	-15.44 ^{**}	-16.00 ^{**}	-15.32 ^{**}
36	L 801× CNH 50	-3.33	-5.84	-15.20	19.13 ^{**}	14.17 ^{**}	1.48	182.61 ^{**}	170.83 ^{**}	140.74 ^{**}	4.88	-5.67	-5.16
37	L 801× GISV 272	-11.80	-19.32 [*]	-16.96	28.63 ^{**}	28.10 ^{**}	14.81 ^{**}	164.73 ^{**}	163.64 ^{**}	136.30 ^{**}	11.01 [*]	3.72	-4.09
38	L 801× CNH 44	-4.15	-10.18	-12.28	26.36 ^{**}	25.83 ^{**}	11.85 ^{**}	166.95 ^{**}	165.83 ^{**}	136.30 ^{**}	-0.78	-9.67 [*]	-11.61 [*]
39	L 801× BS 47	-3.26	-14.66	-4.68	7.87 ^{**}	2.24	1.48	159.84 ^{**}	146.27 ^{**}	144.44 ^{**}	-2.02	-2.81	-21.94 ^{**}
40	L 801× BS 49	-1.65	-5.10	-12.87	5.02	-2.16	0.74	161.00 ^{**}	143.17 ^{**}	150.37 ^{**}	-1.08	-10.59 [*]	-11.08 [*]
	Mean	-1.71	-6.23	-4.50	19.83	13.48	10.63	151.34	138.27	130.82	-5.56	-10.40	-12.04
	Range	-27.27 to 24.42	-27.27 to 20.78	-33.92 to 25.15	1.43 to 33.92	-11.80 to 28.10	-2.96 to 28.15	95.57 to 217.18	64.60 to 205.98	85.19 to 166.67	-26.95 to 11.01	-33.11 to 5.17	-29.14 to 0.38

***, ** Significant at 5% and 1% level, respectively.**

Table 4.17. Estimates of heterosis over mid parent (MP), better parent (BP) and standard check (SH) for ginning outturn (%), 2.5% span length (mm), micronaire value (10^{-6} g/inch) and bundle strength (g/tex) in intra-specific cotton hybrids (*Gossypium hirsutum* L.) during *kharif*, 2013-14

S.No.		Ginning outturn (%)			2.5% span length (mm)			Micronaire value (10^{-6} g/inch)			Bundle strength (g/tex)		
		MP	BP	SH	MP	BP	SH	MP	BP	SH	MP	BP	SH
1	L 762 × CNH 50	-0.17	-1.29	-0.57	13.56**	11.48**	7.92**	3.03	0.00	7.09	5.25**	0.00	3.81*
2	L 762 × GISV 272	2.19	1.84	0.28	12.12**	10.71**	9.93**	1.86	0.74	7.87*	5.54**	1.91	5.78**
3	L 762 × CNH 44	-3.22	-4.69*	-6.15**	7.84**	1.51	11.35**	1.20	-7.35*	-0.79	0.07	-0.29	4.26 ⁹⁹
4	L 762 × BS 47	-1.18	-1.70	-2.18	7.95**	4.96**	7.57**	9.68**	0.00	7.09	-2.00	-4.33**	4.26**
5	L 762 × BS 49	1.54	1.43	0.09	-2.88*	-9.66**	1.65	9.02**	2.21	9.45*	-4.87**	-5.76**	-0.30
6	L 804 × CNH 50	-2.51	-2.79	-2.08	12.27**	5.46**	11.94**	0.79	-0.78	0.00	5.50**	-0.72	5.18**
7	L 804 × GISV 272	2.28	1.08	1.23	6.10**	2.67*	8.98**	-4.28	-7.52*	-3.15	4.58**	0.00	5.94**
8	L 804 × CNH 44	3.30	0.89	1.04	5.91**	4.20**	14.30**	9.70**	4.84	2.36	1.81	1.15	7.15**
9	L 804 × BS 47	-2.77	-3.08	-2.93	5.50**	3.67**	10.05**	6.78	1.61	-0.79	-2.41	-3.77*	4.87**
10	L 804 × BS 49	3.25	2.49	2.65	4.86**	1.89	14.66**	0.41	-1.61	-3.94	-0.50	-0.57	5.33**
11	NDLH 1938 × CNH 50	-4.55	-5.14*	-4.45	10.93**	4.36**	10.40**	-1.57	-2.34	-1.57	6.51**	0.58	5.78**
12	NDLH 1938 × GISV 272	1.66	0.80	0.28	15.62**	12.07**	18.56**	-2.70	-5.26	-0.79	-2.41	-6.37**	-1.52
13	NDLH 1938 × CNH 44	-2.37	-4.34	-4.82*	3.13**	1.29	11.11**	2.93	-2.38	-3.15	0.73	0.43	5.63**
14	NDLH 1938 × BS 47	-0.74	-0.75	-1.23	-1.36	-2.91*	2.72	5.88	0.00	-0.79	-6.61**	-8.24**	0.00
15	NDLH 1938 × BS 49	-1.94	-2.34	-2.84	3.84**	0.74	13.36**	-0.41	-3.17	-3.94	-0.43	-0.72	5.02**
16	L 1057 × CNH 50	-0.84	-1.05	0.09	11.36**	3.02*	13.00**	-0.82	-5.47	-4.72	4.69**	2.33	0.15
17	L 1057 × GISV 272	-1.28	-2.92	-1.80	9.16**	3.99**	14.07**	-2.81	-9.02*	-4.72	1.25	0.62	-1.52
18	L 1057 × CNH 44	2.87	-0.02	1.14	2.16	2.16	12.06**	3.06	1.72	-7.09	-0.60	-3.78*	0.61
19	L 1057 × BS 47	1.83	1.01	2.18	6.63**	3.12*	13.12**	1.75	0.00	-8.66*	-3.61**	-8.52**	-0.30
20	L 1057 × BS 49	1.12	-0.11	1.04	-10.43**	-11.55**	-0.47	2.98	1.68	-4.72	-3.74**	-7.34**	-1.98
21	L 1060 × CNH 50	-8.23**	-8.99**	-8.33**	9.06**	2.92*	8.16**	-2.01	-4.69	-3.94	4.20**	1.39	0.15
22	L 1060 × GISV 272	-1.10	-1.74	-2.65	5.03**	2.14	7.33**	-3.15	-7.52*	-3.15	3.27*	2.16	0.91
23	L 1060 × CNH 44	2.51	0.65	-0.28	4.24**	2.05	11.94**	4.27	0.83	-3.94	-1.95	-4.66**	-0.30
24	L 1060 × BS 47	3.28	3.05	2.55	-0.68	-1.91	3.07*	7.30	3.31	-1.57	-4.32**	-8.80**	-0.61
25	L 1060 × BS 49	1.33	1.13	0.19	-2.12	-5.36**	6.50**	1.67	0.83	-3.94	-1.19	-4.46**	1.07

Table 4.17 (cont.)

S.No.		Ginning outturn (%)			2.5% span length (mm)			Micronaire value (10 ⁻⁶ g/inch)			Bundle strength (g/tex)		
		MP	BP	SH	MP	BP	SH	MP	BP	SH	MP	BP	SH
26	49 JRP× CNH 50	-8.82 ^{**}	-11.34 ^{**}	10.69 ^{**}	6.25 ^{**}	4.81 ^{**}	0.47	-11.49 ^{**}	-18.75 ^{**}	-18.11 ^{**}	6.11 ^{**}	1.03	4.41 ^{**}
27	49 JRP× GISV 272	0.01	-1.33	-3.50	13.99 ^{**}	12.02 ^{**}	11.23 ^{**}	-15.00 ^{**}	-23.31 ^{**}	-19.69 ^{**}	2.59	-0.74	2.59
28	49 JRP× CNH 44	-3.73	-3.88	-8.23 ^{**}	2.93 [*]	-3.56 ^{**}	5.79 ^{**}	0.00	-2.65	-13.39 ^{**}	-5.42 ^{**}	-5.97 ^{**}	-1.67
29	49 JRP× BS 47	-3.69	-5.79	-6.24 ^{**}	2.50 [*]	-0.81	1.65	-6.85 [*]	-8.93 [*]	-19.69 ^{**}	-1.94	-4.47 ^{**}	4.11 [*]
30	49 JRP× BS 49	0.63	-1.16	-2.46	10.27 ^{**}	2.10	14.89 ^{**}	-8.85 [*]	-13.45 ^{**}	-18.90 ^{**}	0.58	-0.58	5.18 ^{**}
31	L 788× CNH 50	1.21	0.97	1.70	6.48 ^{**}	-4.16 ^{**}	11.70 ^{**}	-3.91	-3.91	-3.15	7.21 ^{**}	1.30	6.39 ^{**}
32	L 788× GISV 272	-7.61 ^{**}	-8.75 ^{**}	-8.51 ^{**}	5.81 ^{**}	-2.03	14.18 ^{**}	-0.38	-2.26	2.36	4.45 [*]	0.29	5.33 ^{**}
33	L 788× CNH 44	1.21	-1.20	-0.95	-2.93 ^{**}	-5.78 ^{**}	9.81 ^{**}	7.88 ^{**}	1.56	2.36	0.80	0.58	5.63 ^{**}
34	L 788× BS 47	1.25	0.88	1.14	6.75 ^{**}	0.30	16.90 ^{**}	9.17 ^{**}	2.34	3.15	0.00	-1.82	7.00 ^{**}
35	L 788× BS 49	-2.89	-3.65	-3.41	-1.03	-2.74 [*]	13.36 ^{**}	-3.64	-7.03	-6.30	0.94	0.58	6.39 ^{**}
36	L 801× CNH 50	0.52	-1.00	-0.28	11.77 ^{**}	5.26 ^{**}	11.11 ^{**}	-3.28	-7.81 ^{**}	-7.09	5.84 ^{**}	2.60	2.13
37	L 801× GISV 272	3.96	3.90	1.61	10.56 ^{**}	7.28 ^{**}	13.24 ^{**}	-10.04 ^{**}	-15.79 ^{**}	-11.81 ^{**}	6.13 ^{**}	4.59 ^{**}	4.11 ^{**}
38	L 801× CNH 44	-0.18	-1.30	-3.60	6.53 ^{**}	4.53 ^{**}	14.66 ^{**}	4.80	3.45	-5.51	0.82	-1.60	2.89
39	L 801× BS 47	-12.01 ^{**}	-12.82 ^{**}	-13.25 ^{**}	9.32 ^{**}	7.73 ^{**}	13.71 ^{**}	0.00	-1.72	-10.24 [*]	-1.90	-6.15 ^{**}	2.28
40	L 801× BS 49	-5.28 [*]	-5.76 [*]	-7.00 ^{**}	4.17 ^{**}	0.95	13.59 ^{**}	1.28	0.00	-6.30	2.89 [*]	-0.14	5.63 ^{**}
	Mean	-0.98	-1.97	-2.28	5.83	1.97	10.24	0.36	-3.44	-4.10	0.95	-1.71	3.04
	Range	-12.01 to 3.96	-12.82 to 3.90	-13.25 to 2.65	-10.43 to 15.62	-11.55 to 12.07	-0.47 to 18.56	-15.00 to 9.70	-23.31 to 4.84	-19.69 to 9.45	-6.61 to 7.21	-8.80 to 4.59	-1.98 to 7.15

***, ** Significant at 5% and 1% level, respectively.**

Table 4.18. Estimates of heterosis over mid parent (MP), better parent (BP) and standard check (SH) for uniformity ratio, seed cotton yield per plant (g) and lint yield per plant (g) in intra-specific cotton hybrids (*Gossypium hirsutum* L.) during *kharif*, 2013-14

S.No.		Uniformity ratio			Seed cotton yield per plant (g)			Lint yield per plant (g)		
		MP	BP	SH	MP	BP	SH	MP	BP	SH
1	L 762 × CNH 50	-1.43	-1.43	-3.50*	-3.07	-13.01	-14.94	-5.64	-16.46*	-15.18
2	L 762 × GISV 272	-0.35	-1.40	-1.40	18.39*	16.55	13.97	28.66**	23.06**	24.94**
3	L 762 × CNH 44	-0.70	-2.08	-1.40	6.25	-0.14	-2.35	-0.23	-9.81	-8.44
4	L 762 × BS 47	-3.18	-4.20	-4.20*	-3.44	-6.65	-8.71	-7.05	-11.96	-10.61
5	L 762 × BS 49	3.23	2.86	0.70	41.22**	27.44**	24.62**	39.10**	22.72**	24.59**
6	L 804 × CNH 50	-2.13	-2.82	-3.50*	33.84**	27.00**	9.96	26.61**	17.33	7.58
7	L 804 × GISV 272	0.35	0.00	0.00	5.26	0.73	-4.56	4.68	4.12	-3.50
8	L 804 × CNH 44	-1.40	-2.08	-1.40	37.34**	36.90**	18.53*	37.95**	30.69**	19.82
9	L 804 × BS 47	1.05	0.70	0.70	11.82	8.94	-0.55	5.82	5.31	-3.44
10	L 804 × BS 49	2.49	1.41	0.70	15.31	10.06	-4.70	15.64	6.77	-2.11
11	NDLH 1938 × CNH 50	1.45	0.00	-2.10	15.41	6.99	-2.63	6.61	-3.53	-6.77
12	NDLH 1938 × GISV 272	1.08	-1.40	-1.40	42.96**	40.15**	32.78**	40.55**	37.67**	33.04**
13	NDLH 1938 × CNH 44	0.71	-2.08	-1.40	24.22**	20.82*	9.96	17.45*	8.57	4.92
14	NDLH 1938 × BS 47	-1.08	-3.50*	-3.50*	32.02**	31.82**	20.33*	27.06**	23.23**	19.08*
15	NDLH 1938 × BS 49	6.91**	5.76**	2.80	29.26**	20.52*	9.68	22.18**	10.15	6.45
16	L 1057 × CNH 50	0.71	0.71	-1.40	29.28**	22.95*	5.95	26.54**	18.65*	6.09
17	L 1057 × GISV 272	1.77	0.70	0.70	-10.55	-14.60	-19.09*	-12.77	-14.30	-20.57*
18	L 1057 × CNH 44	-2.11	-3.47*	-2.80	-8.76	-8.83	-21.44*	-7.25	-11.08	-20.49
19	L 1057 × BS 47	1.77	0.70	0.70	12.24	9.09	-0.41	12.68	11.82	1.54
20	L 1057 × BS 49	3.94**	3.57*	1.40	68.46**	61.16**	38.87**	68.08**	56.98**	40.37**
21	L 1060 × CNH 50	3.23*	2.86	0.70	8.79	1.07	-8.44	-1.79	-9.44	-16.05
22	L 1060 × GISV 272	-2.13	-3.50*	-3.50*	0.45	-1.75	-6.92	-2.06	-2.07	-9.22
23	L 1060 × CNH 44	-1.77	-3.47*	-2.80	-1.33	-3.82	-12.86	-0.46	-6.19	-13.04
24	L 1060 × BS 47	-0.71	-2.10	-2.10	34.60**	34.09**	22.41**	25.40**	24.12**	15.07
25	L 1060 × BS 49	3.60*	3.60*	0.70	24.84**	16.64	5.67	24.37**	14.25	5.92

Table 4.18(cont.)

S.No.		Uniformity ratio			Seed cotton yield per plant (g)			Lint yield per plant (g)		
		MP	BP	SH	MP	BP	SH	MP	BP	SH
26	49 JRP× CNH 50	-4.20**	-6.16**	-4.20	-16.62	-17.44	-35.82**	-25.58**	-26.64*	-42.59**
27	49 JRP× GISV 272	-6.57**	-7.53**	-5.59**	-17.31*	-25.40**	-29.32**	-19.21*	-26.46**	-31.84**
28	49 JRP× CNH 44	-6.21**	-6.85**	-4.90**	33.16**	25.56**	8.02	25.55**	20.97*	-0.78
29	49 JRP× BS 47	-0.35	-1.37	0.70	27.66**	17.12	6.92	19.90*	10.15	0.03
30	49 JRP× BS 49	-1.05	-3.42*	-1.40	1.79	0.18	-21.16*	0.16	-0.86	-23.06**
31	L 788× CNH 50	2.51	2.14	0.00	41.53**	34.40**	16.18	41.15**	32.38**	18.29*
32	L 788× GISV 272	0.00	-1.40	-1.40	5.34	0.73	-4.56	-4.09	-5.81	-12.70
33	L 788× CNH 44	0.35	-1.39	-0.70	-1.36	-1.60	-14.94	-1.62	-5.66	-15.70
34	L 788× BS 47	0.00	-1.40	-1.40	19.84*	16.67	6.50	19.76*	18.80*	7.88
35	L 788× BS 49	2.88	2.88	0.00	23.12**	17.60	1.66	17.56*	9.84	-1.85
36	L 801× CNH 50	4.35**	2.86	0.70	-2.58	-8.45	-19.09*	-1.84	-6.40	-19.25*
37	L 801× GISV 272	3.23*	0.70	0.70	-4.83	-8.03	-12.86	-1.13	-4.55	-11.53
38	L 801× CNH 44	-2.14	-4.86**	-4.20*	0.56	-0.78	-12.31	0.31	-2.16	-15.59
39	L 801× BS 47	2.51	0.00	0.00	-9.93	-11.36	-19.09*	-20.41*	-22.40*	-29.53**
40	L 801× BS 49	2.55	1.44	-1.40	-7.95	-12.99	-23.10**	-12.38	-16.78	-28.21**
	Mean	0.33	-0.88	-1.26	13.93	9.26	-1.20	10.76	5.13	-3.16
	Range	-6.57 to 6.91	-7.53 to 5.76	-5.59 to 2.80	-17.31 to 68.46	-25.40 to 61.16	-35.82 to 38.87	-25.58 to 68.08	-26.64 to 56.98	-42.59 to 40.37

*, ** Significant at 5% and 1% level, respectively.

Table 4.19. The best heterotic combinations identified for yield and yield contributing characters in intra-specific hybrids of cotton (*Gossypium hirsutum* L.) during *kharif*, 2013-14

S.No.	Characters	Cross combinations	<i>Per se</i> performance	<i>sca</i> effect	Standard heterosis
1.	Days to 50% flowering	49 JRP × CNH 44	53.67	-5.70 ^{**}	-6.40 [*]
		49 JRP × GISV 272	55.33	-1.45	-3.49
		L 804 × CNH 50	56.33	-3.82 ^{**}	-1.74
2.	Plant height (cm)	NDLH 1938 × BS 49	157.23	5.12	33.82 ^{**}
		L 762 × CNH 50	152.23	10.12 [*]	29.56 ^{**}
		L 1060 × BS 49	151.10	5.23	28.60 ^{**}
3.	Number of monopodia per plant	L 762 × CNH 50	2.67	0.48 ^{**}	37.93 ^{**}
		NDLH 1938 × BS 49	2.63	0.02	36.21 ^{**}
		L 762 × CNH 44	2.60	-0.02	34.48 ^{**}
4.	Number of sympodiaper plant	NDLH 1938 × BS 47	20.87	2.27 ^{**}	19.01 ^{**}
		L 762 × CNH 50	20.77	1.50	18.44 ^{**}
5.	Number of bolls per plant	L 762 × BS 49	71.33	10.97 ^{**}	25.15 ^{**}
		NDLH 1938 × GISV 272	69.67	10.27 ^{**}	22.22 [*]
		L 762 × GISV 272	66.33	7.67 [*]	16.37
6.	Boll weight (g)	L 1057 × BS 49	5.77	0.24 [*]	28.15 ^{**}
		L 788 × BS 47	5.50	0.19	22.22 ^{**}
		L 788 × BS 49	5.47	0.03	21.48 ^{**}
7.	Seed index (g)	49 JRP × CNH 44	12.00	0.01	166.67 ^{**}
		NDLH 1938 × CNH 50	11.93	1.52 ^{**}	165.19 ^{**}
		L 1060 × CNH 50	11.80	0.82 [*]	162.22 ^{**}
8.	Lint index (g)	L 1060 × CNH 44	6.22	0.32	0.38
		NDLH 1938 × CNH 50	6.08	0.72 ^{**}	-1.94
		49 JRP × GISV 272	6.03	0.30	-2.74
9.	Ginning outturn (%)	L 804 × BS 49	36.17	0.65	2.65
		L 1060 × BS 47	36.13	1.58 ^{**}	2.55
		L 1057 × BS 47	36.00	0.66	2.18
10.	2.5% span length (mm)	NDLH 1938× GISV 272	33.43	1.52 ^{**}	18.56 ^{**}
		L 788× BS 47	32.97	1.51 ^{**}	16.90 ^{**}
		49 JRP× BS 49	32.40	2.44 ^{**}	14.89 ^{**}
11.	Micronaire value (10 ⁻⁶ g/inch)	L 762× BS 49	4.63	0.17	9.45 [*]
		L 762× GISV 272	4.57	0.07	7.87 [*]
		L 762× CNH 50	4.53	0.03	7.09

Table 4.19 (cont.)

S.No.	Characters	Cross combinations	<i>Per se</i> performance	<i>sca</i> effect	Standard heterosis
12.	Bundle strength (g/tex)	L 804× CNH 44	23.47	0.32	7.15
		L 788× BS 47	23.43	0.26	7.00
		L 788× CNH 50	23.30	-0.05	6.39**
13.	Uniformity ratio	NDLH 1938× BS 49	49.00	1.06	2.80
		L 1057× BS 49	48.33	-0.01	1.40
		L 762× BS 49	48.00	0.46	0.70
14.	Seed cotton yield per plant (g)	L 1057× BS 49	334.67	79.42**	38.87**
		NDLH 1938× GISV 272	320.00	51.52**	32.78**
		L 762× BS 49	300.33	40.88**	24.62**
15.	Lint yield per plant (g)	L 1057× BS 49	119.19	28.07**	40.37**
		NDLH 1938 × GISV 272	112.96	19.07**	33.04**
		L 762× GISV 272	106.08	19.22**	24.94**

* Significant at 5% level

** Significant at 1% level

Appendix I. Mean performance of 40 intra-specific hybrids and 13 parents of cotton (*Gossypium hirsutum* L.) during kharif, 2013-14

S. No.	Character	Days to 50% flowering	Plant height (cm)	Number of monopodia per plant	Number of sympodia per plant	Number of bolls per plant	Boll weight (g)	Seed index (g)	Lint index (g)
1	L 762 × CNH 50	60.33	152.23	2.67	20.77	55.33	4.37	9.90	5.35
2	L 762 × GISV 272	58.33	128.77	2.30	19.47	66.33	4.83	10.57	5.77
3	L 762 × CNH 44	63.00	135.57	2.60	15.97	53.00	4.73	10.30	5.11
4	L 762 × BS 47	67.00	132.73	1.50	18.33	49.67	4.90	8.33	4.39
5	L 762 × BS 49	56.67	139.60	2.03	18.00	71.33	4.73	9.27	5.03
6	L 804 × CNH 50	56.33	124.00	1.60	18.80	62.00	4.53	10.57	5.56
7	L 804 × GISV 272	57.33	112.90	1.73	17.33	51.00	5.00	10.70	5.94
8	L 804 × CNH 44	61.33	131.90	2.30	18.43	65.67	4.80	10.87	6.01
9	L 804 × BS 47	65.33	129.50	0.63	20.43	55.33	4.77	10.13	5.27
10	L 804 × BS 49	64.33	133.67	1.93	19.77	51.33	5.03	9.63	5.47
11	NDLH 1938 × CNH 50	60.33	149.67	2.40	20.77	58.00	4.73	11.93	6.08
12	NDLH 1938 × GISV 272	56.67	127.93	2.20	17.10	69.67	5.10	9.83	5.37
13	NDLH 1938 × CNH 44	69.33	135.33	2.50	15.80	56.00	5.07	9.90	5.01
14	NDLH 1938 × BS 47	65.00	147.33	1.30	20.87	59.67	5.27	9.00	4.81
15	NDLH 1938 × BS 49	61.67	157.23	2.63	16.80	56.00	5.20	10.50	5.48
16	L 1057 × CNH 50	61.00	149.10	1.30	17.33	53.67	5.17	9.47	5.15
17	L 1057 × GISV 272	59.67	128.83	0.93	16.33	42.67	5.33	8.73	4.61
18	L 1057 × CNH 44	59.00	136.13	2.17	18.90	44.67	4.97	10.67	5.91
19	L 1057 × BS 47	65.67	141.33	0.93	14.67	52.67	5.43	8.90	5.01
20	L 1057 × BS 49	60.67	150.33	1.93	19.33	66.00	5.77	10.73	5.94
21	L 1060 × CNH 50	64.67	135.67	1.73	17.10	50.33	5.23	11.80	5.61
22	L 1060 × GISV 272	63.67	124.53	1.30	15.30	59.67	4.50	10.60	5.55
23	L 1060 × CNH 44	67.00	131.67	1.93	15.80	52.33	4.77	11.50	6.22
24	L 1060 × BS 47	69.33	143.33	0.40	18.33	65.33	5.00	9.53	5.40
25	L 1060 × BS 49	57.33	151.10	2.03	17.20	58.67	5.37	10.57	5.78
26	49 JRP × CNH 50	59.67	122.33	1.17	14.67	37.67	4.47	11.20	5.15
27	49 JRP × GISV 272	55.33	99.23	1.00	14.63	44.67	4.73	11.70	6.03
28	49 JRP × CNH 44	53.67	124.97	1.30	16.20	54.67	5.07	12.00	5.75
29	49 JRP × BS 47	68.67	132.33	0.87	14.67	54.67	4.93	11.63	5.74

S. No.	Character	Days to 50% flowering	Plant height (cm)	No. of monopodia per plant	No. of sympodia per plant	No. of bolls per plant	Boll weight (g)	Seed index (g)	Lint index (g)
30	49 JRP × BS 49	63.00	123.23	1.97	16.70	40.00	5.23	11.30	5.91
31	L 788 × CNH 50	62.00	140.07	0.93	16.30	57.00	5.30	8.83	4.95
32	L 788 × GISV 272	59.00	122.67	1.30	15.53	50.33	5.23	9.53	4.55
33	L 788 × CNH 44	55.33	130.20	1.63	16.33	50.67	4.73	10.60	5.69
34	L 788 × BS 47	66.67	134.47	0.97	16.67	59.33	5.50	10.17	5.63
35	L 788 × BS 49	64.67	142.33	1.97	15.23	52.33	5.47	10.20	5.25
36	L 801 × CNH 50	62.33	135.53	1.10	17.77	48.33	4.57	10.83	5.88
37	L 801 × GISV 272	56.67	120.53	1.60	15.20	47.33	5.17	10.63	5.95
38	L 801 × CNH 44	58.67	137.30	1.97	14.90	50.00	5.03	10.63	5.48
39	L 801 × BS 47	65.67	128.90	1.10	16.10	54.33	4.57	11.00	4.84
40	L 801 × BS 49	62.33	145.33	1.93	17.30	49.67	4.53	11.27	5.51
41	L 762	61.67	128.47	2.27	19.40	62.33	3.67	3.67	5.78
42	L 804	55.00	109.53	1.33	17.13	50.67	3.93	3.93	5.63
43	NDLH 1938	59.67	125.00	2.27	19.27	59.67	3.90	3.90	4.99
44	L 1057	60.33	122.60	1.53	18.17	58.67	4.53	4.53	6.90
45	L 1060	62.67	111.80	1.27	16.47	53.67	4.43	4.43	6.16
46	49 JRP	57.33	99.20	0.93	15.67	50.67	3.60	3.60	5.50
47	L 788	56.67	119.07	1.33	15.93	51.67	5.37	5.37	6.25
48	L 801	57.67	120.07	1.30	16.27	48.67	4.00	4.00	4.98
49	CNH 50	61.67	119.13	0.50	15.20	51.33	3.67	3.67	6.23
50	GISV 272	56.67	104.70	0.30	16.20	58.67	4.03	4.03	5.73
51	CNH 44	59.33	114.93	1.30	14.63	55.67	3.97	3.97	6.07
52	BS 47	64.33	111.03	0.50	17.07	63.67	4.47	4.47	4.90
53	BS 49	60.67	117.00	1.93	18.00	52.33	4.63	4.63	6.17
54	LAHH5	57.33	117.50	1.93	17.53	57.00	4.50	4.50	6.20
	Mean	61.03	129.44	1.56	17.11	54.67	4.77	8.78	5.55
	C.V. (%)	3.29	5.54	14.28	8.16	10.95	3.57	7.98	6.17
	S.E.	1.16	4.14	0.13	0.81	3.46	0.10	0.40	0.20
	C.D. 5%	3.25	11.60	0.36	2.26	9.69	0.28	1.13	0.55
	Range Lowest	53.67	99.20	0.30	14.63	37.67	3.60	3.60	4.39
	Range Highest	69.33	157.23	2.67	20.87	71.33	5.77	12.00	6.90

S. No.	Character	Ginning outturn (%)	2.5% span length (mm)	Micronaire value (10 ⁻⁶ g/in)	Bundle strength (g/tex)	Uniformity ratio	Seed cotton yield per plant (g)	Lint yield per plant (g)
1	L 762 × CNH 50	35.03	30.43	4.53	22.73	46.00	205.00	72.02
2	L 762 × GISV 272	35.33	31.00	4.57	23.17	47.00	274.67	106.08
3	L 762 × CNH 44	33.07	31.40	4.20	22.83	47.00	235.33	77.74
4	L 762 × BS 47	34.47	30.33	4.53	22.83	45.67	220.00	75.89
5	L 762 × BS 49	35.27	28.67	4.63	21.83	48.00	300.33	105.79
6	L 804 × CNH 50	34.50	31.57	4.23	23.03	46.00	265.00	91.34
7	L 804 × GISV 272	35.67	30.73	4.10	23.20	47.67	230.00	81.94
8	L 804 × CNH 44	35.60	32.23	4.33	23.47	47.00	285.67	101.74
9	L 804 × BS 47	34.20	31.03	4.20	22.97	48.00	239.67	81.99
10	L 804 × BS 49	36.17	32.33	4.07	23.07	48.00	229.67	83.12
11	NDLH 1938 × CNH 50	33.67	31.13	4.17	23.17	46.67	234.67	79.16
12	NDLH 1938 × GISV 272	35.33	33.43	4.20	21.57	47.00	320.00	112.96
13	NDLH 1938 × CNH 44	33.53	31.33	4.10	23.13	47.00	265.00	89.08
14	NDLH 1938 × BS 47	34.80	28.97	4.20	21.90	46.00	290.00	101.11
15	NDLH 1938 × BS 49	34.23	31.97	4.07	23.00	49.00	264.33	90.38
16	L 1057 × CNH 50	35.27	31.87	4.03	21.93	47.00	255.33	90.08
17	L 1057 × GISV 272	34.60	32.17	4.03	21.57	48.00	195.00	67.44
18	L 1057 × CNH 44	35.63	31.60	3.93	22.03	46.33	189.33	67.51
19	L 1057 × BS 47	36.00	31.90	3.87	21.83	48.00	240.00	86.22
20	L 1057 × BS 49	35.60	28.07	4.03	21.47	48.33	334.67	119.19
21	L 1060 × CNH 50	32.30	30.50	4.07	21.93	48.00	220.67	71.28
22	L 1060 × GISV 272	34.30	30.27	4.10	22.10	46.00	224.33	77.08
23	L 1060 × CNH 44	35.13	31.57	4.07	21.83	46.33	210.00	73.84
24	L 1060 × BS 47	36.13	29.07	4.17	21.77	46.67	295.00	97.70
25	L 1060 × BS 49	35.30	30.03	4.07	22.13	48.00	254.67	89.93
26	49 JRP × CNH 50	31.47	28.33	3.47	22.87	45.67	154.67	48.74
27	49 JRP × GISV 272	34.00	31.37	3.40	22.47	45.00	170.33	57.87
28	49 JRP × CNH 44	32.33	29.83	3.67	21.53	45.33	260.33	84.25
29	49 JRP × BS 47	33.03	28.67	3.40	22.80	48.00	257.67	84.93
30	49 JRP × BS 49	34.37	32.40	3.43	23.03	47.00	190.00	65.33

S.No	Character	Ginning outturn (%)	2.5% span length (mm)	Micronaire (10 ⁻⁶ g/in)	Bundle strength (g/tex)	Uniformity ratio	Seed cotton yield per plant (g)	Lint yield per plant (g)
31	L 788 × CNH 50	35.83	31.50	4.10	23.30	47.67	280.00	100.44
32	L 788 × GISV 272	32.23	32.20	4.33	23.07	47.00	230.00	74.12
33	L 788 × CNH 44	34.90	30.97	4.33	23.13	47.33	205.00	71.58
34	L 788 × BS 47	35.63	32.97	4.37	23.43	47.00	256.67	91.60
35	L 788 × BS 49	34.03	31.97	3.97	23.30	47.67	245.00	83.33
36	L 801 × CNH 50	35.13	31.33	3.93	22.37	48.00	195.00	68.56
37	L 801 × GISV 272	35.80	31.93	3.73	22.80	48.00	210.00	75.11
38	L 801 × CNH 44	33.97	32.33	4.00	22.53	45.67	211.33	71.67
39	L 801 × BS 47	30.57	32.07	3.80	22.40	47.67	195.00	59.83
40	L 801 × BS 49	32.77	32.03	3.97	23.13	47.00	185.33	60.96
41	L 762	34.69	27.30	4.53	22.73	46.67	235.67	86.20
42	L 804	35.29	29.93	4.13	23.20	47.33	208.67	77.85
43	NDLH 1938	35.05	29.83	4.20	23.03	45.33	219.33	82.05
44	L 1057	35.64	30.93	3.87	21.43	46.67	207.67	75.92
45	L 1060	34.91	29.63	4.03	21.63	46.33	218.33	78.71
46	49 JRP	33.53	27.03	3.57	22.63	48.67	183.67	64.56
47	L 788	35.32	32.87	4.27	23.00	46.33	208.33	75.87
48	L 801	34.41	29.77	3.87	21.80	45.33	213.00	73.25
49	CNH 50	35.49	26.30	4.27	20.47	46.67	187.33	66.45
50	GISV 272	34.46	28.00	4.43	21.17	47.67	228.33	78.69
51	CNH 44	33.64	30.93	3.77	22.90	48.00	207.33	69.65
52	BS 47	35.06	28.90	3.73	23.87	47.67	220.00	77.10
53	BS 49	34.77	31.73	3.97	23.17	46.33	189.67	65.90
54	LAHH5	35.23	28.20	4.23	21.90	47.67	241.00	84.91
	Mean	34.53	30.65	4.06	22.51	47.02	231.35	80.48
	C.V.(%)	2.81	1.57	5.02	1.87	2.06	10.45	10.57
	S.E.	0.56	0.28	0.12	0.24	0.56	13.95	4.91
	C.D. 5%	1.57	0.78	0.33	0.68	1.57	39.12	13.76
	Range Lowest	30.57	26.30	3.40	20.47	45.00	154.67	48.74
	Range Highest	36.17	33.43	4.63	23.87	49.00	334.67	119.19

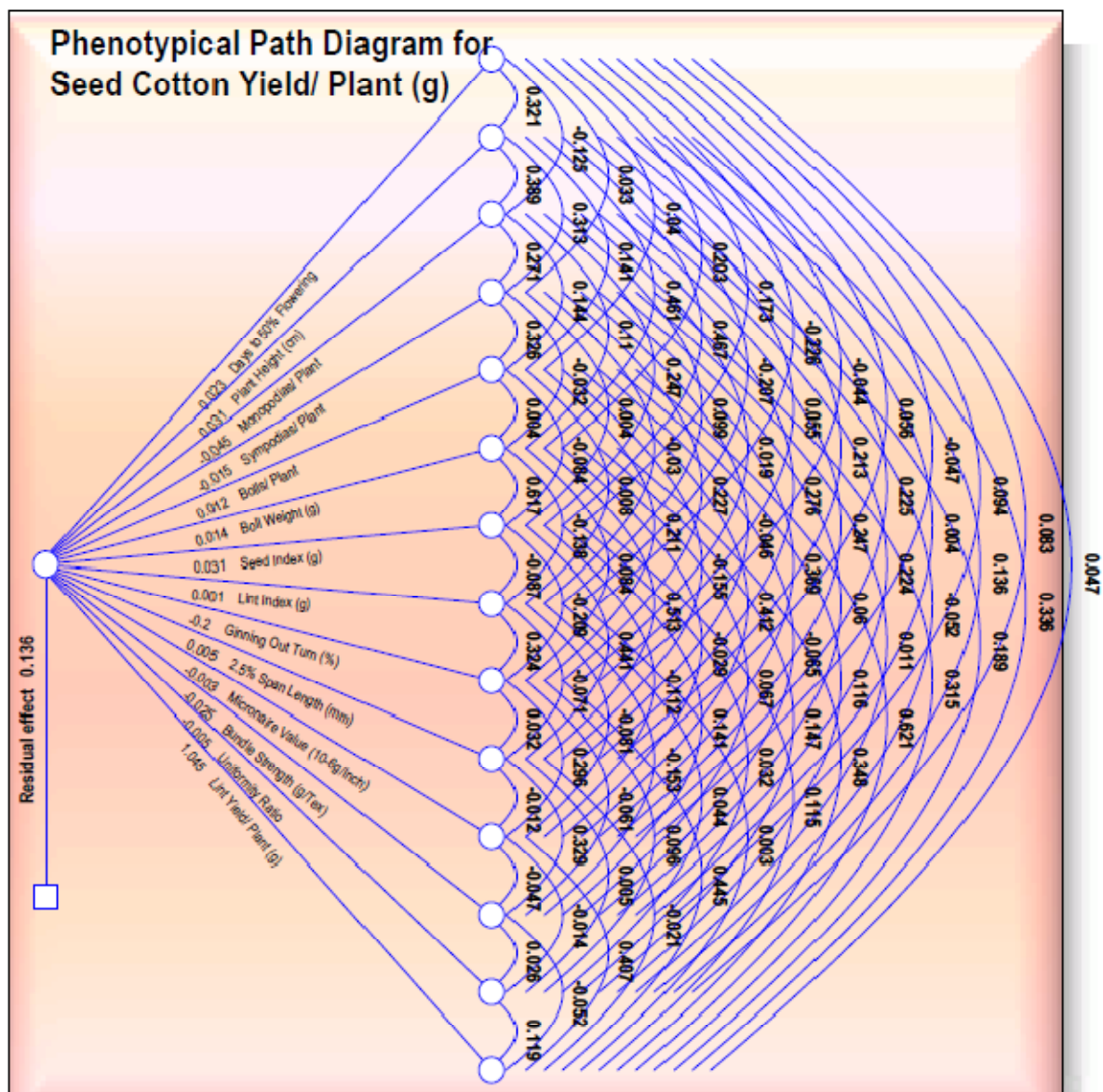


Fig. 1. Phenotypic path diagram showing the cause and effect relationship of yield components with seed cotton yield per plant in cotton

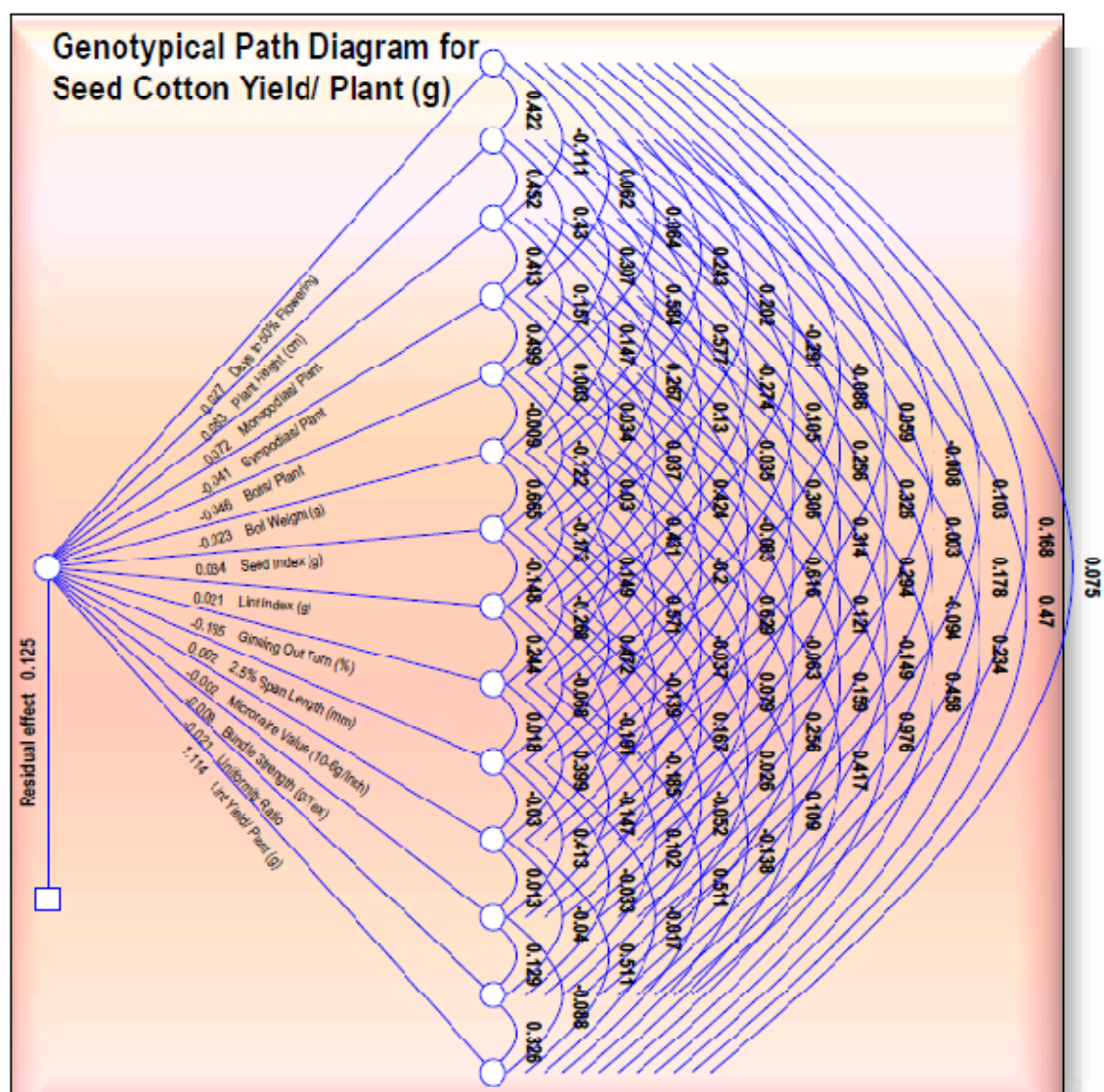


Fig. 2. Genotypic path diagram showing the cause and effect relationship of yield components with seed cotton yield per plant in cotton