Electronic Journal of Plant Breeding, 8(4): 1159-1168 (Dec 2017)
ISSN 0975-928X
DOI: 10.5958/0975-928X.2017.00168.5

Research Article

Combining ability and gene action studies on seed cotton yield and its related traits in diploid cotton (*Gossypium arboreum* L.)

R.D. Vekariya[1*], S. Nimbal[2], Aashima Batheja[2], R.S. Sangwan[2] and S. Mandhania[2]
[1]Navsari Agricultural University, Navsari - 496390
[2]Cotton Section, Department of Genetics and Plant Breeding, CCS Haryana Agricultural University, Hisar-125004
E-mail : rajesh22vk@gmail.com

(Received: 30 May 2017; Revised: 26 Dec 2017; Accepted: 28 Dec 2017)

Abstract

Present study aims to estimate GCA of the parents and SCA of GMS based diploid cotton hybrids for yield and its associate traits. The magnitude of the components of GCA and SCA variances showed preponderance of non-additive gene action for all the characters studied. Based on the GCA effect, the male parent HD 517 was the best general combiner for seed cotton yield, number of bolls, boll weight, number of monopods and days to first flower. HD 534 was best combiner for ginning out turn, boll weight, number of seeds per boll and days to first flower for earliness. Among the females, DGMS 34 was the best combiner for the characters *viz.*, seed cotton yield, number of bolls and number of seeds per boll. The hybrids DGMS 34 x HD 517, DGMS 34 x HD 523 and DGMS 2 x HD 528 recorded superior *per se* performance for number of bolls, boll weight and seed cotton yield and other characters. For seed cotton yield and yield related traits the good SCA effects were observed in the hybrids DGMS 2 x HD 528, DGMS 1 x HD 432, DGMS 34 x HD 517 and DGMS 34 x HD 523 along with good *per se* performance.

Key words

Gossypium arboreum L.; per se performance; GCA; SCA; Gene action; Line x Tester

Introduction

Cotton is the world's foremost natural fibre crop. India is the only country in the world that grows not only all the four cultivated species of cotton but also intra and inter specific hybrids on a commercial scale. *Desi* cottons are still cultivated on large scale in India because of their good genetic and agronomic base, resistance to pests and diseases, drought tolerance and suitability for rainfed conditions. After the introduction of Bt cotton, the area of *desi* cotton has decreased continuously due to smaller boll size and low potential of yield, but now there is a big demand of short staple cotton for denim and surgical cotton and there is renewed interest in *desi* cotton. Genetic diversity is the first step to create unique gene combinations for superior new cultivars. For a sound hybridization program parents should be selected not only on the basis of their diversity but also on the basis of their combining ability effects. Knowledge on combining ability is useful for selection of desirable parents for exploitation of hybridity and transgressive expressions. Combining ability studies also give idea about the nature and magnitude of gene action involved in the inheritance of seed cotton yield and its related characters. Line x Tester analysis (Kempthorne, 1957) reveals general combining ability (GCA) effects of parents and specific combining ability (SCA) effects of hybrids. Evaluation of breeding materials for general combining ability and specific combining ability as well as to study the extent of For heterosis for yield and yield contributing characters are prerequisites for any breeding program aimed in development of hybrids. Keeping in view the above points, the present investigation. was carried out with the objectives to know the extent of GCA effects and SCA effects for seed cotton yield and its related traits in Gossypium arboreum

Materials and methods

The present investigation was undertaken to study the genetic potential of genotypes and combining ability in F_1 hybrids of *Gossypium arboreum* L.. An experiment was conducted at, CCS Haryana Agricultural University, Hisar, during *kharif* 2016 in a randomized block design with three replications sown in two rows plot of 6.0 m length with spacing of 67.5 cm between rows and 60 cm between the plants. All the recommended cultural package of practices and need based plant protection measures were followed from sowing to till harvesting the crop. The combining ability, analysis was performed to determine genetic potential of genotypes and inherent potential of parental stocks to produce high yielding hybrids by using Line x Tester analysis with four females, *viz.*, DGMS 1, DGMS 2, DGMS 9 and DGMS 34 and fifteen male parents, *viz.*, HD 432, HD 503, HD 514, HD 517,. , HD 432, HD 503, HD 514, HD 517, HD 522, HD 523, HD 532, H D 533, HD 534, CNA 398, LD 1026, LD 1019 and NDLA 3020. The material for the present investigation thus comprised of 80 *entries i.e.*, 60 hybrids developed in Line x Tester mating design (Kempthorne,1957) along with their parents and one standard check (AAH 1).. Five plants randomly selected were tagged and labeled for recording the observations on ten characters *viz.*, days to first flower, number of monopods, number of bolls, boll weight, plant height, seed cotton yield per plant, ginning out turn, seed index, lint index and number of seeds per boll.

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Statistical analysis was carried out by using the mean values over five sample plants through O PSTAT Package

Results and discussion

Estimates of variances due to general and specific combining ability for all ten characters under study are presented in **Table 1**. General combining ability variances for female parents were significant for all the characters. In the males, general combining ability variances for all the ten characters were significant for all traits studied except for lint index and days to first flower. It was also confirmed by the results reported in earlier studies of Jatoi *et al.* (2010) for boll weight, Solanke *et al.* (2015) and Kumar *et al.* (2014) for single plant yield.

In the current study, analysis of combining ability revealed that magnitude of SCA variance was greater than GCA variance for all the characters studied (**Table 1**) indicating that all the traits are governed by non-additive gene action, which could be exploited for the improvement of these traits by heterosis and population improvement methods. Similar findings were reported by Shanti and Selvaraj (1995), Patel *et al* (2010), Senthilkumar *et al.* (2010) and Pushpam *et al* (2015)

The study of *per se* performance revealed that male parent CNA 398 reported higher mean value for seed cotton yield (106.90 g/plant), number of bolls (50.00), boll weight (2.39 g/plant), number of monopods (4.20) and lint index (3.56 g/plant). The second best mean performance male parent for seed cotton yield (96.74 g/plant) was HD 523 which was also found to be best combiner for number of bolls (48.93), boll weight (2.36 g/plant) and lint index (3.562g/plant). However, male parent HD 514 was found to have higher mean for number of monopods (4.20) and seed index (5.26 g/plant). Among the females, DGMS 34 reported higher mean performance for the characters *viz*., seed cotton yield (104.20 g/plant), number of bolls (50.93), boll weight (2.41 g/plant), number of monopods (4.40) and ginning outturn (45.72%). DGMS 9 also showed early flowering (73.00 days), dwarfness (168.00cm) and high lint index (4.09%). These parents can be exploited via hybridization for improving the characters The through pedigree breeding (Hassan *et al.,* 2000 and Usharanani *et al., 2014)*

The estimates of GCA effects (**Table 2**) showed that male parent HD 517 was the best general combiner for seed cotton yield, number of bolls, boll weight, number of monopods and days to first follow by CNA 398. However, among males, parent HD 534 was found the best combiner for ginning out turn, boll weight, number of seeds per boll and days to first flower for earliness. Male parent HD 432 was found best combiner for seed cotton yield, number of bolls, boll weight and number of monopods. For dwarfness HD 527 was found to be the best combiner. The male parents HD 517 and HD 534 were found to be best combiners for earliness *i.e.* early of monopods. For dwarfness HD 527 was found to be the best combiner. The male parents HD 517 and HD 534 were found to be best combiners for earliness *i.e.* early maturity. Male parents CNA 398 and HD 534 were the best combiners for ginning out turn and LD 1026 was the best combiner for seed index. Among the female DGMS 34 was the best combiner for the characters *viz*., seed cotton yield, number of bolls and number of seeds per boll. Best combining male and female parents along with the poorest combiners for various characters are presented in **Table 3**. In general, none of the male and female parents was found to possess high GCA effects for all the characters under study. The respective best combiners for various characters could be used for improvement in those characters. However, considering the economic importance of various characters HD 517, LD 1026, HD 432, CNA 398, HD 528 and HD 534 among males and DGMS 34 among females may be used for future breeding programmes. Similar results were reported by Nimbalkar *et al.* (2004), Kalpande *et al.* (2008), Laxman (2010) and Usharani *et al.* (2014). Based on the high *per se* performance and high GCA effects, among male parents, CNA 398 and among female parents, DGMS 34 were considered as having the best *per se* performance as well as general combining ability for seed cotton yield, number of bolls, boll weight and number of monopods.

SCA effects alone are not appropriate for exploitation of heterosis because the hybrid with low mean value may also possess high SCA effect. Hence, the cross combinations were identified based on two criteria *viz., per se* performance and the gene action involved in the crosses for further exploitation. On the basis of *per se* performance the better performing hybrids were DGMS 34 x HD 517 and DGMS 34 x HD 523 for number of bolls and seed cotton yield; DGMS 2 x HD 528 for number of bolls, boll weight and seed cotton yield; DGMS 1 x HD 432 for number of monopods and seed cotton yield; cross DGMS 2 x HD 534 for dwarfness, number of seeds per boll, number of bolls, boll weight and seed cotton yield. These findings confirmed with the findings of Ahuja and Dhayal (2007), Karademir *et al.* (2009), Khan *et al.* (2009) and Laxman (2010). Best cross combinations with SCA effect for different characters along with *per se* performances have been presented in Table 5.

None of the crosses was found desirable for all the characters. The estimates of specific combining ability effects are provided in **Table 4.** Based on SCA effects, the hybrid DGMS 2 x HD 528 followed by DGMS 1 x HD 432 were the top specific combiners for the seed cotton yield per plant and both these crosses were also found to be the top specific cross combiners for number of bolls with poor x good general combining parents *i.e.* Both non-additive and additive gene interactions were involved in these crosses. In this situation, we could go for recombination breeding for improvement of a particular trait. Similar findings were reported by Muthu *et al.* (2005), Ahuja and Dhayal (2007), Senthilkumar *et al* (2010) Usharani *et al.*, (2014) and Pushpam *et al* (2015).The cross combinations of DGMS 9 x HD 533 and DGMS 34 x HD 523 had the highest SCA effect for boll weight. The cross DGMS 34 x HD 532 exhibited top SCA for seed index and showed significant SCA effects for seed cotton yield and number of bolls, and it was a good x good GCA combination. High negative SCA effects for days to first flower were depicted by hybrid DGMS 2 x HD 523, which was a combination of good x poor combining parent, indicating that both additive and dominance variance were important for this character. The cross combinations DGMS1 x HD 517 showed highest SCA effect for dwarfness.

Table 6 reveals the performance in terms of *per se*, GCA, SCA and heterosis in those ten better performing crosses on the basis of seed cotton yield. The *per se* performance of the hybrids was not necessarily associated with the GCA effects of parent. These finding are in agreement with the findings of Nimbalkar *et al.* (2004), Sakhare *et al.* (2005), Patel *et al.* (2007), Patel *et al.* (2010), Rajamani *et al.* (2013), Senthilkumar *et al.* (2010), Usharani *et al.*, (2014), Patel and Chaudhary (2015) and Pushpam *et al.* (2015). The cross combination having the highest SCA effects for seed cotton yield *viz.*, DGMS 2 x HD 528, was not having high general combining ability for both parents. The cross with the maximum economic heterosis and high GCA *i.e.*, DGMS 34 x HD 517 (good x good GCA) was not good for its SCA effects

However, crosses DGMS 34 (good) x HD 517 (good), DGMS 1 (poor) x HD 432 (average), DGMS 2 (poor) x HD 528 (good) and DGMS 34 (good) x HD 523 (good) showed good heterosis for seed cotton yield, high *per se* performance along with good GCA effects. Hence these crosses demand their further testing in varying environments. Thus for an effective selection of the parents for sound hybridization program, the study must take into consideration the *per se* performance and combining ablity effects.

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DOI: 10.5958/0975-928X.2017.00168.5

Table 1.Combining ability analysis for thirteen characters in *Gossypium arboreum* L.

Source of variance	D.F	Days to first flower	Plant height	No. of monopods	No. of bolls	Boll weight/ Boll	Seed cotton yield /plant	No. of seeds /boll	Ginning out turn	Seed index	Lint index
Replication	2	4.67	6.28	0.369	72.44	0.07	7.26	1.11	0.50	0.04	0.30
Lines	3	96.91**	2228.61**	9.71**	303.57**	0.09**	1726.11**	38.33**	144.65**	0.38**	1.47*
Testers	14	1.80	520.36**	0.69**	367.81**	0.04**	1622.03**	7.81**	4.10**	0.43**	0.25
Lines x Testers	42	5.29**	183.03**	0.48**	145.27**	0.03**	675.46**	5.76**	7.03**	0.46**	0.27*
Error	118	2.784	80.71	0.25	9.22	0.01	14.15	1.42	3.626	0.12	0.18
σ^2(GCA)		3.09	83.61	0.33	13.68	0.12	115.12	1.21	5.10	-0.00	0.04
σ^2(SCA)		36.89	1101.18	3.82	277.70	0.21	3530.09	24.56	58.69	0.98	0.68
σ^2(GCA)/ σ^2(SCA)		0.08	0.08	0.09	0.05	0.57	0.03	0.05	0.09	-0.004	0.08

Table 2. General combining ability effects of parents for different characters in *Gossypium arboreum* L.

Female parents	Days to first flower	Plant height (cm)	No. of monopods	No. of bolls	Boll weight/ Boll (g)	Seed cotton yield/plant(g)	No. of seeds/boll	Ginning out turn (%)	Seed index (g)	Lint Index (g)
DGMS 1	-0.25	-1.23	0.45**	0.78	0.00	0.32	-0.39	-1.71**	0.09	-0.12
DGMS 2	-1.49**	-4.57*	-0.58**	-2.50**	0.01	-4.84**	0.45	-0.96*	0.02	-0.18*
DGMS 9	2.03**	10.29**	0.29**	-1.99*	-0.04	-3.84**	-1.08**	2.39**	-0.13*	0.20*
DGMS 34	-0.29	-4.49*	-0.16	3.70**	0.03	8.36**	1.02**	0.28	0.01	0.10
SE(d)	0.35	1.89	0.11	0.85	0.03	1.05	0.25	0.40	0.07	0.09
Male parents										
HD 432	-0.37	-2.07	0.44*	1.38**	0.13**	5.24**	-0.83	0.84	-0.14	0.09
HD 503	-0.24	5.72	0.12	-1.67**	-0.05*	-7.24**	0.59	-1.07	0.00	-0.02

HD 514	0.80	2.65	0.32	-2.98**	-0.05*	-7.22**	-0.01	1.27	0.19	0.22
HD 517	-1.48*	13.05**	0.48*	6.65**	0.08**	16.37**	-0.76	0.24	-0.04	0.05
HD 533	-0.32	-6.78	0.16	-1.12**	-0.03	-2.90**	-0.63	-0.28	0.01	-0.02
HD 522	0.22	-4.12	-0.30	-1.40**	0.00	-2.62**	-0.85	1.36	-0.30*	-0.10
HD 534	-1.44*	-2.82	0.13	-1.72**	0.04*	-2.18**	1.16*	1.55*	-0.18	0.05
HD 532	0.20	6.15	-0.03	-0.72	-0.07**	-3.56**	-0.73	-1.38	0.14	-0.25

**Significant at 1% level of significance.
*Significant at 5% level of significance.

Table 2. Contd…

Male parents	Days to first flower	Plant height (cm)	No. of monopods	No. of bolls	Boll weight/ Boll (g)	Seed cotton yield/plant (g)	No. of seeds/boll	Ginning out turn (%)	Seed index (g)	Lint Index (g)	Oil content (%)	Protein content (%)	Gossypol content (%)
HD 523	0.11	-3.57	-0.02	2.30**	0.02	8.93**	0.74	-1.77*	-0.17	-0.32	0.27	0.35	-0.08**
CNA 398	-0.04	-6.10	0.42*	4.13**	0.05*	9.38**	0.87	1.58*	0.17	-0.05	0.98**	-0.28	-0.02
HD 528	0.41	-6.75	-0.22	4.53**	0.06**	9.86**	0.57	-0.23	0.07	-0.02	0.53	2.03**	0.12**
HD 527	-0.32	-7.48*	0.13	-8.08**	-0.16**	-20.44**	-1.23*	0.44	0.23	0.20	-0.15	1.21	0.06*
LD 1026	0.18	9.58*	0.43*	10.42**	0.13**	22.31**	0.09	-0.81	0.32*	0.06	0.69*	0.56	0.02
LD 1019	0.07	5.60	-0.41*	-4.07**	-0.03	-7.31**	1.16*	0.23	-0.29*	0.12	-0.97**	-0.68	0.09**
NDLA 3020	1.58*	-3.07	-0.27	-7.48**	-0.12**	-18.63**	-0.16	-1.54*	0.00	-0.02	-0.65*	0.12	0.02
SE(d)	0.68	3.67	0.21	0.39	0.02	0.49	0.49	0.78	0.14	0.17	0.30	0.59	0.02

Table 3. Above average and poor general combining parents for different characters

Characters	Male parent			Female parent
	Above average combiners		Poor combiners	Above average combiners
	1st	2nd		
Days to first flower	HD 517 (-1.48*)	HD 534 (-1.44*)	NDLA 3020 (1.58*)	DGMS 2 (-1.49**)
Plant height	HD 527 (-7.48*)	HD 528 (-6.75)	HD 517 (13.05**)	DGMS 2 (-4.57*)
No. of monopods	HD 517 (0.48*)	HD 432 (0.44*)	LD 1019 (-0.41*)	DGMS 1 (0.45**)
No. of bolls	LD 1026 (10.42**)	HD 517 (6.65**)	HD 527 (-8.08**)	DGMS 34 (3.70**)
Boll weight/boll	LD 1026 (0.13**)	HD 432 (0.13**)	NDLA 3020 (-0.12**)	DGMS 34 (0.03)
Seed cotton yield per plant	LD 1026 (22.31**)	HD 517 (16.37**)	HD 527 (-20.44**)	DGMS 34 (8.36**)
No. of seed	HD 534 (1.16*)	LD 1019 (1.16*)	HD 527 (-1.23*)	DGMS 34 (1.02**)
GOT	CNA 398 (1.58*)	HD 534 (1.55*)	NDLA 2030 (-1.54*)	DGMS 9 (2.39**)
Seed index	LD 1026 (0.32**)	HD 527 (0.23)	HD 522 (-0.30**)	DGMD 1 (0.09)
Lint index	HD 514 (0.22)	HD 527 (0.20)	HD 523 (-0.32)	DGMS 9 (0.20**)

**Significant at 1% level of significance.
*Significant at 5% level of significance.

Electronic Journal of Plant Breeding, 8(4): 1159-1168 (Dec 2017)
ISSN 0975-928X
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Table 4.Specific combining ability effects of hybrids for different characters in *Gossypium arboreum* L.

Cross	Days to first flower	Plant height (cm)	No. of monopod	No. of bolls	Boll weight/ boll (g)	Seed cotton yield/ plant (g)	No. of seeds/ boll	Ginning out turn (%)	Seed index (g)	Lint Index (g)
DGMS 1 x HD 432	-0.15	-8.99	0.83*	15.90**	0.08	33.75**	-0.46	-1.18	-0.03	-0.17
DGMS 1 x HD 503	-1.71	-3.77	0.50	6.88**	-0.01	13.84**	-1.08	-1.07	0.29	0.10
DGMS 1 x HD 514	-2.70*	-1.04	0.10	4.73**	0.05	3.92**	-3.21**	0.21	0.36	-0.03
DGMS 1 x HD 517	-0.61	-15.10*	-0.01	-7.17**	0.01	-13.18**	-1.00	3.10*	-0.67*	-0.25
DGMS 1 x HD 533	-0.37	-3.94	0.50	3.80*	0.05	13.04**	-0.40	-0.05	-0.09	0.04
DGMS 1 x HD 522	-0.64	8.40	-0.01	-4.12**	-0.13*	-13.72**	0.03	-0.08	0.17	0.34
DGMS 1 x HD 534	0.56	5.96	0.22	-1.27	0.00	-5.28**	0.35	-1.28	-0.23	-0.03
DGMS 1 x HD 532	0.35	5.33	-0.21	-3.27*	-0.01	-5.56**	-1.10	-1.50	-0.07	-0.15
DGMS 1 x HD 523	0.81	6.18	-0.36	-5.08**	-0.07	-7.55**	0.24	-0.63	-0.31	-0.46
DGMS 1 x CAN 398	0.99	9.71	-0.06	2.35	-0.06	4.92**	0.97	-0.62	0.59*	0.07
DGMS 1 x HD 528	1.24	4.36	-0.10	-13.92**	-0.19**	-33.05**	1.00	-1.31	0.02	0.17
DGMS 1 x HD 527	0.47	-2.70	-0.51	0.63	0.03	3.80*	1.40	0.36	-0.22	0.14
DGMS 1 x LD 1026	-0.01	-5.64	-0.50	2.01	0.04	5.36**	0.75	1.16	0.42	0.34
DGMS 1 x LD 1019	0.97	2.55	-0.18	-4.38**	0.08	-6.17**	0.69	0.90	-0.04	-0.10
DGMS 1 x NDLA 3020	0.17	-1.32	0.02	2.90	0.12*	5.89**	1.80	1.99	-0.19	0.00
DGMS 2 x HD 432	0.42	4.02	-0.10	-9.22**	0.13*	-14.34**	1.37	0.20	0.20	0.04
DGMS 2 x HD 503	0.93	7.57	-0.07	-1.50	0.12*	-2.14	1.48	1.76	0.06	0.12
DGMS 2 x HD 514	1.79	-0.16	0.07	-2.45	0.06	3.75*	2.42*	-1.27	0.11	-0.04
DGMS 2 x HD 517	1.36	1.24	-0.04	-5.55**	0.01	-10.94**	1.30	-1.38	0.61*	0.28
DGMS 2 x HD 533	-0.40	-2.26	-0.64	3.48*	-0.12*	2.34	0.97	0.17	-0.33	0.06
DGMS 2 x HD 522	1.96	-10.26	-0.25	0.36	0.06	5.08**	1.56	-0.16	-0.23	-0.23
DGMS 2 x HD 534	-2.77*	-12.89	0.05	0.41	-0.03	-3.70*	-2.22*	-1.05	0.54	0.20
DGMS 2 x HD 532	-1.38	2.47	0.15	-4.59**	-0.09	-10.87**	0.00	-0.90	-0.41	-0.17
DGMS 2 x HD 523	-2.79*	-5.48	-0.07	-2.87	-0.07	-12.99**	-0.47	1.21	-0.05	0.25
DGMS 2 x CNA 398	-1.54	-3.94	0.23	5.50**	0.07	14.22**	0.00	0.95	-0.29	0.13
DGMS 2 x HD 528	0.08	1.71	0.47	15.03**	0.12*	34.78**	-0.43	1.29	0.23	0.08
DGMS 2 x HD 527	-0.60	1.77	0.25	-2.55	-0.14*	-9.75**	-1.10	-0.92	-0.52	-0.51
DGMS 2 x LD 1026	2.70*	3.51	0.27	0.48	0.08	7.86**	-0.08	-1.13	0.11	-0.11
DGMS 2 x LD 1019	-1.29	15.36*	-0.42	5.23**	-0.04	8.22**	-2.08*	0.50	0.33	0.20
DGMS 2 x NDLA 3020	1.11	-2.64	0.12	-1.75	-0.16**	-11.53**	-2.70**	0.71	-0.37	-0.31
DGMS 9 x HD 432	-1.39	2.69	-0.44	0.41	-0.11	-3.92*	0.16	-1.84	-0.02	-0.30
DGMS 9 x HD 503	-0.42	1.71	-0.81*	-1.28	-0.05	-3.98*	-1.25	-0.28	-0.65*	-0.07
DGMS 9 x HD 514	0.84	11.64	0.46	-1.43	-0.03	-3.27	0.15	0.30	-0.13	-0.03
DGMS 9 x HD 517	0.38	1.37	0.25	-0.99	-0.05	-1.80	0.30	-1.43	0.09	-0.11

Electronic Journal of Plant Breeding, 8(4): 1159-1168 (Dec 2017)
ISSN 0975-928X
DOI: 10.5958/0975-928X.2017.00168.5

DGMS 9 x HD 533	0.09	-2.46	0.48	-1.76	0.14*	-2.25	0.23	-1.82	0.39	-0.06
DGMS 9 x HD 522	-0.98	-0.13	-0.39	4.59**	0.03	9.38**	0.86	0.39	-0.17	-0.14
DGMS 9 x HD 534	0.88	-4.09	0.04	-1.09	-0.06	3.01	0.25	1.01	0.16	0.19
DGMS 9 x HD 532	0.71	-4.19	0.41	4.77**	-0.01	8.03**	1.40	3.15*	-0.35	-0.24
DGMS 9 x HD 523	1.27	-0.48	-0.07	-1.38	0.00	-2.01	-0.07	-1.20	0.32	0.22
DGMS 9 x CNA 398	2.02	-7.08	0.16	-11.88**	-0.10	-23.57**	0.06	-0.77	-0.09	-0.25
DGMS 9 x HD 528	-0.17	-0.69	-0.41	2.66	0.06	4.38*	-1.17	0.98	-0.24	0.02
DGMS 9 x HD 527	-0.78	-4.76	0.24	-1.66	0.05	-0.87	-0.30	0.96	0.21	-0.06
DGMS 9 x LD 1026	-1.48	10.17	-0.01	7.44**	0.08	8.02**	-0.89	-0.78	-0.02	-0.23
DGMS 9 x LD 1019	-1.03	-4.18	0.24	5.92**	0.06	14.01**	-0.55	1.42	0.28	0.64
DGMS 9 x NDLA 3020	0.06	0.49	-0.16	-4.33**	-0.01	-5.16**	0.83	0.82	0.22	0.44
DGMS 34 x HD 432	1.12	2.28	-0.06	-7.09**	-0.10	-15.50**	-1.07	2.81	-0.16	0.43
DGMS 34 x HD 503	1.20	-5.51	0.37	-4.10**	-0.07	-7.71**	0.85	-0.41	0.30	-0.14
DGMS 34 x HD 514	-0.58	-10.44	-0.63	-0.85	-0.08	-4.40*	0.65	0.77	-0.33	0.11
DGMS 34 x HD 517	-1.14	15.19*	-0.20	15.19**	0.04	25.92**	-0.60	-0.29	-0.03	0.09
DGMS 34 x HD 533	0.67	8.66	-0.34	-5.52**	-0.07	-13.13**	-0.80	1.69	0.02	-0.04
DGMS 34 x HD 522	-0.34	1.99	0.86*	-0.84	0.04	-0.74	-2.44*	-0.14	0.23	0.04
DGMS 34 x HD 534	0.53	11.03	-0.31	1.95	0.09	5.97**	1.62	1.32	-0.46	-0.36
DGMS 34 x HD 532	0.32	-3.61	-0.34	3.08*	0.11	8.40**	-0.30	0.14	0.83**	0.57
DGMS 34 x HD 523	0.51	-0.22	0.82*	9.33**	0.14*	22.54**	0.30	0.61	0.03	-0.01
DGMS 34 x CNA 398	-1.47	1.31	-0.33	4.03**	0.09	4.44*	-1.03	0.45	-0.22	0.05
DGMS 34 x HD 528	-1.15	-5.37	0.04	-3.77*	0.01	-6.11*	0.60	-0.96	-0.01	-0.27
DGMS 34 x HD 527	0.91	5.69	0.02	3.58*	0.06	6.82**	0.00	-0.40	0.53	0.42
DGMS 34 x LD 1026	-0.60	-8.04	0.23	-9.92**	-0.19**	-21.24**	0.22	0.75	-0.51	0.00
DGMS 34 x LD 1019	1.35	-13.72	0.36	-6.77**	-0.10	-16.05**	1.95*	-2.81	-0.57*	-0.74*
DGMS 34 x NDLA 3020	-1.33	3.48	0.02	3.18*	0.04	10.80**	0.07	-3.51*	0.35	-0.13
SE(d)	1.36	7.34	0.41	1.47	0.06	1.82	0.97	1.55	0.29	0.35

**Significant at 1% level of significance.
*Significant at 5% level of significance.

Table 5. Above average specific cross combination for different characters along with *per se* performance

Characters	Above average cross combination			
	1st	Mean	2nd	Mean
Days to first flower (days)	DGMS 2 x HD 523 (-2.79*)	71.30	DGMS 2 x HD 534 (-2.77*)	71.37
Plant height(cm)	DGMS 1 x HD 517 (-15.10*)	173.00	DGMS 34 x LD 1019 (-13.72)	163.67
No. of monopods	DGMS 34 x HD 522 (0.86*)	4.07	DGMS 1 x HD 432 (0.83*)	5.13
No. of bolls	DGMS 1 x HD 432 (15.90**)	54.93	DGMS 34 x HD 517 (15.19**)	60.93
Boll weight/boll(g)	DGMS 9 x HD 533 (0.14*)	2.26	DGMS 34 x HD 523 (0.14*)	2.37
Seed cotton yield per plant(g)	DGMS 2 x HD 528 (34.78**)	114.83	DGMS 1 x HD 432 (33.75**)	114.34
No. of seed	DGMS 2 x HD 514 (2.42*)	31.72	DGMS 34 x LD 1090 (1.95*)	28.40
GOT(%)	DGMS 9 x HD 532 (3.15*)	44.98	DGMS 1 x HD 517 (3.10*)	43.34
Seed index(g)	DGMS 34 x HD 532 (0.83**)	5.39	DGMS 2 x HD 517 (0.61*)	5.00
Lint index(g)	DGMS 9 x LD 1090 (0.64)	4.23	DGMS 34 x HD 532 (0.57)	3.70

SCA value in parenthesis
**Significant at 1% level of significance.
*Significant at 5% level of significance

Table 6.Performance in terms of *per se*, GCA, SCA and heterosis for the ten better performing crosses on the basis of seed cotton yield

Crosses	*Per se* performance of crosses for seed cotton yield	GCA of parents P_1	P_2	SCA of crosses	Heterosis for seed cotton yield
DGMS 34 x HD 517	125.68	G	G	G	G
DGMS 34 x HD 523	114.86	G	A	G	G
DGMS 2 x HD 528	114.83	P	A	G	G
DGMS 1 x HD 432	114.34	P	A	G	G
DGMS 1 x LD 1026	123.03	P	G	A	G
DGMS 9 x LD 1026	101.52	P	G	A	G
DGMS 2 x LD 1026	100.37	P	G	A	G
DGMS 34 x CNA 398	97.21	G	A	A	G
DGMS 2 x CNA 398	93.79	P	A	A	G
DGMS 1 x CNA398	89.65	P	A	A	G