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GENETIC CHARACTERIZATION OF A *GOSSYPIUM HIRSUTUM* CROSS PUSA 45-3-6 × PUSA 19-27

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ABSTRACT

The generation means analysis of data of an intra-*hirsutum* cross Pusa 45-3-6 × Pusa 19-27 revealed presence of dominance and epistatic interactions in the genetic control of important yield components of boll number, boll weight, number of sympodia, number of monopodia, plant height and biological yield, while only additive gene action was significant for first fruiting node number. For harvest index, both additive and dominance effects were significant but epistasis was absent.

In F_3 generation, mean-squares for "Between families variation" was significantly higher than mean-squares for "Within family variation" for all the traits except for harvest index. This suggested making of biparental matings between selected plants of different families complementing for yield components and postponing the selection to advance generations from such crosses for achieving significant genetic gain.

Key Words : *Gossypium hirsutum*, generation means, gene action, narrow sense heritability

For genetic improvement of field crop varieties, it is axiomatic to a plant breeder that the genetic variability present in the germplasm may be utilised either for direct selection or for hybridization for further augmentation of the variability through recombination. Selection for the quantitative characters can be effective only when the segregating generations of a cross posses potential genetic variability which is further channelised through an appropriate breeding methodology in order to develop superior genotypes.

The present study was undertaken to study the genetic variability in an intra-*hirsutum* cross, detect and quantify the genetic behaviour of yield and its components and suggest an appropriate breeding methodology with the view to develop high yielding pure lines through component breeding.

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MATERIALS AND METHODS

The material for the present investigation consisted of parental generations, F_1 generation and segregating generations viz. F_2, F_3, BC_1 and BC_2 of a *Gossypium hirsutum* cross Pusa 45-3-6 (P_1) × Pusa 19-27 (P_2). Pusa 45-3-6 is tall with spreading habit, high biological yield, high boll number, high boll weight and high harvest index, while Pusa 19-27 is a dwarf genotype characterised by moderately high harvest index and low biological yield.

The parents and F_1s were grown in winter season nursery at Coimbatore during 1990-91. The back crosses to either parents were attempted at Coimbatore. During *kharif* 1991 material of Intra-*hirsutum* cross Pusa 45-3-6 X Pusa 19-27 comprising of parents, F_1s, F_2s, BC_1s, BC_2s were grown at I.A.R.I., New Delhi in a compact family block design with two replications. The parents and F_1s were grown in a single row, the F_2s in six rows and back crosses in two rows each. The characters under study were 1) Plant height, 2) First fruiting node number, 3) Monopodia, 4) Sympodia, 5) Boll number, 6) Boll weight, 7) Economic yield, 8) Biological yield, 9) Harvest index, 10) Seed index, 11) Ginning percentage and 12) Lint index.

Genetic parameters viz. genotypic coefficient of variation (gcv), mean performance of various generations, narrow sense heritability, (h^2_n) and expected genetic gain were estimated by the standard formulae[1]. The generation mean analysis was carried out as per Hayman[2] and F_3 analysis of variance was done as per Snedcor and Cochron [3].

RESULTS AND DISCUSSION

The mean performance of the basic generations P_1, P_2, F_1, F_2, BC_1, BC_2 of cross Pua 45-3-6 × Pusa 19-27 (Table 1) showed existence of substantial variability in the material for different characters under study. Parents showed wide divergence for all the characters studied, more particularly so for economic yield, biological yield, harvest index, plant height, fruit fruiting node number and boll number.

In general F_1 mean performance was better than either of the parents for boll number, economic yield and biological yield. It appears that P_1 with its large boll number, high boll weight, biological and economic yield contributed largely towards the increased boll number, boll weight, biological yield and economic yield of the F_1. Probably, it carried the dominant genes for these traits. Although P_1 had more sympodia, it did not contribute much towards better performance of the trait in F_1. Similar was the case for first fruiting node number in P_2. However, P_2 seems to be contributing to the increased monopodia in F_1.

Table 1. Mean performance of six generations of *G. hirsutum* cross Pusa 45-3-16 × Pusa 19-7 for different characters

Character	Generation					
	P_1	P_2	F1	BC1	BC2	F2
Plant height (cm)	119.08 ± 2.84	65.21 ± 2.37	125.88 ± 2.12	103.58 ± 4.85	93.71 ± 1.98	95.38 ± 1.08
First fruiting node number	10.60 ± 0.46	7.95 ± 0.16	10.01 ± 0.38	10.29 ± 0.59	9.74 ± 0.24	9.48 ± 0.12
Monopodia	0.17 ± 0.40	0.39 ± 0.14	0.76 ± 0.17	0.88 ± 0.27	0.71 ± 0.10	0.92 ± 0.73
Sympodia	14.25 ± 2.21	12.26 ± 0.67	14.21 ± 0.55	14.70 ± 0.57	13.74 ± 0.40	15.04 ± 0.21
Boll number	16.33 ± 2.41	8.84 ± 0.85	23.47 ± 2.14	16.41 ± 1.89	16.27 ± 0.92	20.00 ± 0.72
Boll weight@ (g)	12.15 ± 0.76	9.06 ± 0.52	11.30 ± 0.34	11.38 ± 0.41	11.39 ± 0.17	10.55 ± 0.14
Economic yield (g)	68.48 ± 10.60	23.88 ± 2.26	89.04 ± 7.08	59.58 ± 7.66	60.81 ± 3.93	65.86 ± 2.41
Biological yield (g)	137.35 ± 17.12	58.67 ± 4.67	196.98 ± 14.57	140.26 ± 15.78	143.77 ± 7.88	148.68 ± 4.94
Harvest index (%)	48.80 ± 2.71	40.42 ± 1.68	45.73 ± 1.80	42.87 ± 2.75	43.73 ± 0.88	43.98 ± 0.51

@Three bolls weight

Significant decline in the performance of F_2 mean from F_1 mean was observed for economic yield, biological yield, plant height, boll number and boll weight (Tables 1) suggesting presence involvement of dominance and epistatic interactions (Table 2).

Table 2. Scaling tests of generation means for *Gossypium hirsutum* cross Pusa 45-4-6 x Pusa 10-27 for different characters

Character	Scaling test			
	A	B	C	D
Plant height	37.80* ± 10.31	−3.67 ± 5.08	−54.43* ± 7.09	−6.53 ± 5.65
First fruiting node number	−0.03 ± 1.33	1.52* ± 0.63	−0.65 ± 1.01	−1.07 ± 0.68
Monopodia	0.83 ± 0.69	0.34 ± 0.30	1.67* ± 0.62	0.25 ± 0.32
Sympodia	0.94 ± 2.30	1.01 ± 1.18	5.27* ± 2.68	1.66 ± 0.61
Boll number	−6.98 ± 4.98	0.23 ± 2.95	7.89 ± 5.76	7.32* ± 2.55
Boll weight@	−0.69 ± 1.17	2.42* ± 0.71	−1.61 ± 1.27	1.67* ± 0.52
Economic yield	−38.36* ± 19.74	8.70 ± 10.82	−7.0 ± 20.27	11.33 ± 9.78
Biological yield	53.81 ± 38.71	31.89 ± 21.96	4.74 ± 39.42	13.33 ± 20.20
Hrvest index	−8.79 ± 6.39	1.31 ± 3.04	−4.76 ± 5.23	1.36 ± 3.07

@Three bolls weight * Significant at P = 0.05

in expression of these traits. The generation mean analysis (Table 3) suggested that only additive × dominant epistatic interactions along with additive effect was significant for economic yield. Similar results were also reported earlier [4-7]. However, the significant inbreeding depression observed may have occurred because of sampling error in estimation of F_2 mean coupled with dissipation of additive × dominance interactions which might have inflated the F_1 mean.

Table 3. Estimates of genetic components of generation means based on 6-parameter model (Hayman, 1958) for *Gossypium hirsutum* cross Pusa 45-3-6 × Pusa 19-27

Character	Components					
	m	[d]	[h]	[i]	[j]	[l]
Plant height	79.09* ± 11.46	26.94* ± 1.85	18.39 ± 33.08	13.06 ± 11.31	–34.13* ± 11.09	28.41 ± 22.09
First fruiting node number	7.14* ± 1.38	1.32* ± 0.25	6.51 ± 4.03	2.14 ± 1.36	–1.55 ± 1.37	–3.63 ± 2.75
Monopodia	0.75 ± 0.68	–0.08 ± 0.22	0.69 ± 1.94	–0.50 ± 0.64	0.49 ± 1.00	–0.67 ± 1.31
Sympodia	16.28* ± 1.67	0.99 ± 1.15	–3.74 ± 4.68	–3.32* ± 1.21	–0.07 ± 2.47	1.37 ± 3.21
Boll number	27.23* ± 5.25	3.75* ± 1.28	–25.15 ± 14.55	–14.64* ± 5.09	–7.49 ± 4.93	21.39* ± 10.21
Boll weight@	7.27* ± 1.14	1.55* ± 0.46	9.11* ± 3.22	3.34* ± 1.05	–3.11* ± 1.28	–5.07* ± 2.18
Economic yield	68.84* ± 20.20	22.30* ± 5.41	–32.12 ± 57.30	–22.66 ± 19.56	–47.06* ± 20.16	52.32 ± 39.45
Biological yield	124.68* ± 41.36	39.34* ± 11.05	23.74* ± 0.20			
Harvest index#	47.33* ± 6.34	4.19* ± 1.60	–11.80* ± 1.54			

* : Significant at P = 0.05; @ Three bolls weight; # Three parameter model

For biological yield and harvest index, both of which are important yield components, [*d*] and [*h*] were significant. Presence of dominance explains the inbreeding depression observed in F_2 for these two traits. The improvement in biological yield can be brought about by delaying selection for 2-3 generations so that effect of dominance component is reduced[8]. In case of harvest index where variability appears to be low in the material, pedigree method may be quite useful since only additive component was significant (Table 3).

A moderately high broad sense heritability accompanied by moderately low expected genetic advance for plant height inspite of inbreeding depression observed in F_2 may probably be due to low genetic variability in the material for this trait (Table 4). Selection for such traits may not be rewarding as that in traits with high heritability and high expected genetic gain.

Boll weight exhibited moderate to low narrow sense heritability accompanied by moderately low genetic gain (Table 6). The generation mean analysis (Table 3)

Table 4. Estimates of broadsense heritability (h^2 b), expected genetic gain (EGG), heterosis and inbreeding depression in *Gossypium hirsutum* cross Pusa 45-3-6 × Pusa 19-27

Character	Heterosis Over better parent (%)	Inbreeding depression (%)	h^2_b	ECG
Plant height	5.70 ± 3.45	24.00* ± 2.37	64.0	21.5
First fruiting node number Monopodea	25.90* ± 0.41	5.29 ± 0.39	35.0	12.9
Sympodia	−0.28 ± 2.26	−5.90 ± 0.58	25.0	58.7
Boll number	43.72* ± 3.22	14.78 ± 2.26	-	-
Boll weight	−7.00 ± 0.83	7.00* ± 0.36	45.0	47.8
Economic yield	30.02* ± 12.78	35.19* ± 7.48	1.0	0.3
Bilogical yield	30.27 ± 22.47	24.52* ± 15.38	37.0	40.0
Harvest index	−6.20 ± 6.50	3.83 ± 1.87	47.0	46.0

*: Significant at P = 0.05; -:non-significant estimates of relevant genetic parameters
@Three bolls weight; ECG : expected genetic gain

had revealed that dominance and its interactions were quite prominent in the genetic control of the trait. Therefore, selection would be quite ineffective in early generations. The present results are in confirmity with the reports of Atta *et al*[9] and Thombre *et al.* [4].

Boll number showed predominance of [i] and [l] type interactions besides the significant positive effect [*d*]. The dominance effect [*h*] was non-significant for boll number. Dhillon and Singh[9] noted that inclusion of [*h*] which was not actually involved in a three parameter model [*m, d, h*] caused inflation of the χ^2 value indicating inadequacy of the model. The inbreeding depression for the trait could be due to dissipation of dominance × dominance and other higher order interactions in F_2.

For boll number, present results contradict the report of Silva and Alves[6]. It may be however kept in mind that the results obtained from generation mean analysis of a particular cross are applicable to that cross alone and can not be extrapolated to other crosses.

Surprisingly, monopodia and sympodia exhibited negative imbreeding depression with F_2 mean value higher than F_1. Similar results were reported by Baker and Verhalen[10] for micronair value. This negative imbreeding depression could possibly be due to sampling error accompanying F_2 mean. For these traits, zero heritability and nil expected genetic gain were obtained (Table 6). This indicated that the material lacked genetic variability for these traits. Only additive × additive [i] was significant for sympodia and that too negative while for monopodia, dominance × dominance interaction appeared prominent (Table 3) but because of high standard error it did not reach significance level.

When we consider the characters of plant frame such as plant height and first fruiting node number, the additive component was significant in the inheritance of these two traits (Table 3). However, additive × dominance component was significant for plant height but [*d*] and [*j*] were opposite in sign indicating duplicate epistasis.

F_3 generation

The ANOVA for "Between" and "Within" family variations (Table 5) indicated significant difference among F_3 lines for all the traits except harvest index. Except

Table 5. Between and within families ANOVA for twelve quantitative traits in F_3 generation of *Gossypium hirsutum* cross 45-3-6 × Pusa 19-27

Source of Variation	d.f.	Plant height	First fruiting node number	Monopodia	Sympodia	Boll number	Boll weight	Economic yield	Biological yield	Harvest index	Seed index	Ginning percentage	Lint index
		Mean squares											
Between families	29	688.8^*	3.18^*	0.30^{ns}	12.0^*	61.8^*	4.40^*	1003.9^+	3617.1^*	62.3^{ns}	1.45^+	23.3^*	0.94^*
Within families	60	134.4	1.82	0.25	6.6	31.9	2.62	655.4	2206.1	66.6	1.01	10.1	0.44

*: Significant at P = 0.05, + : Significant at P = 0.10

for plant height and first fruiting node number, the F_3 means were higher than their parental means for all characters (Table 6). With respect to F_2, higher mean values in desirable direction were observed for harvest index, economic yield, boll weight and sympodia, more or less similar mean values were observed for plant height and biological yield, but means for boll number and first fruiting node number moved towards undesirable direction. The significant feature was increase in mean harvest index in F_3 in response to selection pressure applied in F_2 generation. Despite decrease in boll number, F_3 mean for economic yield was increased. The major component contributing to this increase was boll weight (F_3 mean exhibited 24% increase over F_2). This might be result of correlated response in boll weight as a result of selection for harvest index in F_2.

The phenotypic coefficients of variation was higher than genotypic coefficients of variation for all the traits in F_3 (Table 6). This indicated that the apparent variation in each trait is not only due to genotypes but also due to the influence of environment, so selection for such traits sometimes may be misleading.

Table 6. Estimates of genetic parameters in F_3 generation of *G. hirsutum* cross Pusa 45-3-6 × Pusa 19-27

Parameter / Character	mean	range	Coefficient of variation (%)	Narrow sense heritability (%)	Expected genetic gain (% of mean)
Plant height	93.17	53.00 - 135.00	14.77	42.1	29.74
First fruiting node number	10.51	7.00 - 15.00	6.29	-	-
Monopodia	0.37	0.00 - 3.00	34.11	-	-
Sympodia	19.81	11.00 - 28.00	7.03	-	-
Boll number	18.08	6.00 - 40.00	17.54	12.1	13.16
Boll weight@ (g)	13.10	6.80 - 18.80	6.53	16.3	7.37
Economic yield (g)	70.18	15.20 - 191.50	15.76	8.2	10.00
Biological yield (g)	141.19	42.60 - 367.70	15.60	18.8	22.21
Harvest index (%)	50.35	18.00 - 74.00	0.06	7.7	3.50
Seed index	9.64	5.80 - 12.88	3.87	n.a	n.a
Ginning percentage	31.46	18.83 - 49.49	7.26	n.a	n.a
Lint index	4.45	2.11 - 8.24	9.80	n.a	n.a

@Three bolls weight; n.a - not estimated; - zero heritability.

High narrow sense heritability accompanied with relatively high expected genetic gain (Table 6) for plant height indicates the importance of additive gene effects and simple pedigree selection may be quite effective for this trait.

Moderate heritability, coupled with moderate expected genetic gain for boll number, biological yield and economic yield in F_3 as compared to high broadsense heritability and high expected gain in F_2 (Table 4) for these traits indicate either dissipation of variance due to dominance effects and interactions as a result of fixation of some of the loci in heterozygous phase, or reduction in phenotypic variance due to correlated response to selection for harvest index in F_2.

Lint index and ginning percentage exhibited high broadsense heritability (Table 4) accompanied with moderate to low genetic gain, indicating the existence of low genetic variability in these traits in the present material. The high heritability exhibited was due to low influence of environment rather than high genotypic variability, so selection for such traits may not be rewarding. Harvest index exhibited very low genotypic coefficient of variation accompanied with zero heritability estimates. This strongly suggested that the material lacked presence of sufficient genetic variability for this trait. Monopodia was found to be highly under the influence of environment.

Moderate values of genotypic and phenotypic coefficients of variation and moderate heritability and expected genetic gain for boll number, economic yield and biological yield suggested possibilities of genetic improvement in yield through recombination breeding and recurrent selection.

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