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Impact of mating systems on genetic variability in segregating generations of Asiatic cotton (*Gossypium* sp.)

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Abstract

The impact of mating systems in generation of variability in an intra and interspecific cross of Asiatic cotton (*Gossypium* sp.) were studied and compared in F_4 generation. Both intra and interspecific crosses exhibited variable response specific to character and the mating system used to advance the generations. Reduced variability observed in the intra-specific cross for some of the characters in the populations advanced through random intermating and open pollination as compared to self pollination could be attributed to linkage disequilibrium. On the contrary, reverse trend was observed in the inter-specific cross where open pollination and selective intermating showed higher genetic variability as compared to self pollinated population. Significant changes in character association were observed in F_4 population of both intra and inter-specific crosses following three mating systems. Such changes are expected if linkages are broken due to recombination. Population raised through selective intermating in the intra-specific cross offered good scope to release a wider range of transgressive segregants over the other two mating systems while self and open pollination provided similar advantage in the inter-specific cross.

Key words: Asiatic cotton, mating systems, linkage disequilibrium, transgressive segregation.

Introduction

In India the two cultivated species of Asiatic cotton *viz.*, *Gossypium arboreum* and *Gossypium herbaceum* are grown in about 28% of the total area. *Desi* cottons are well adapted to wide range of climatic conditions. They are tolerant to both sucking pests and boll worms but are poor yielders as compared to *hirsutum* cotton varieties and hybrids, which are highly susceptible to pests and diseases. Of late, the farmers are inclined to grow *desi* cotton owing to low input cost required for their management and therefore, there is a need to develop high yielding varieties of *desi* cotton coupled with desired fibre properties. However, it appears that due to limited genetic variability available in the cultivated diploid species it has not been possible to break the yield plateau. Cotton being an often cross pollinated crop, there is little chance for new recombinants to occur after the F_2 generation. Failure of conventional breeding methods paved the way for modification of the conventional pedigree system. Basing the theoretical calculations on the linkage associations between parents of diverse genetic backgrounds, selective intermating has been suggested by Hanson(1) and by Miller and Rawling(2). The present study was aimed to evaluate the nature of genetic variability generated in three derived populations of an intra-specific *G. arboreum* cross and an inter-specific (*G. arboreum* × *G. herbaceum*) cross following three different mating systems *viz.*, selective intermating, open (random) pollination and self pollination in F_3 generation and to compare the magnitude and nature of variability released in F_4 generation and the effect of mating systems in dissipation of undesirable linkages and changes in character associations. The behaviour of transgressive segregants observed following three mating systems has also been examined.

Materials and methods

Seventy five single plants each in F_3 generation of an intra-specific MDL 2556 × PA 141(*G. arboreum* × *G. arboreum*) and an inter-specific cross MDL 2452 × Jaydhar (*G. arboreum* × *G. herbaceum*) involving four different parents (Table 1) were selected and subjected to three different mating systems (25 single plants for each mating system) *viz.*, selective intermating, open (random) pollination and self pollination in *kharif* 2000-2001. These selected plants were advanced to short bulks and evaluated in three replications during *kharif* season of 2001-2002 at Agricultural Research Station, Mudhol. Observations were recorded for characters such as number of bolls/plant, boll weight, seed cotton yield/plant, seed index, lint index, halo length and ginning out turn. The three resulting populations of intra- and inter-specific crosses were assessed for parameters of genetic variability and the nature of associations through correlation analysis. The behaviour of transgressive segregants for yield and its components was examined by analysing the frequency distribution of populations advanced following the three mating systems.

Table 1. Agronomic characteristics of parents involved in an intra-*arboreum* and an inter-specific cross

Character	MDL 2556	PA 141	MDL 2452	Jaydhar
Number of bolls/plant	11.57±1.91	11.75±1.43	21.93±1.38	16.2± 0.53
Boll weight (g)	02.24±0.11	02.29±0.08	02.36±0.04	01.82±0.05
Seed cotton yield/plant (g)	25.04±3.60	26.27±2.67	51.44±3.31	29.32±01.0
Seed index(g)	06.29±0.26	06.12±0.19	05.98±0.14	06.03±0.05
Lint index (g)	03.31±0.10	03.97±0.11	03.93±0.08	02.92±0.07
Halo length (mm)	22.98±0.50	24.52±0.64	22.42±0.55	21.44±0.53
Ginning out turn (%)	34.91±1.67	35.91±1.54	39.21±0.54	33.71±0.27

Results and discussion

The study of genetic parameters of means and variability (Table 2) revealed that the three populations derived from self, open and selective intermating effected in intra (MDL 2556 × PA 141) and interspecific (MDL 2452 × Jaydhar) crosses exhibited similar magnitude of population means and CV values for all the characters except number of bolls and seed cotton yield per plant. However, open and self pollinated populations of the intra-specific cross (MDL 2556 × PA 141) had high range of mean values for ginning out turn as compared to its intermated population while reverse trend was observed in the populations derived from an inter-specific cross (MDL 2452 × Jaydhar). On the contrary population derived through selective intermating of the intra-specific cross showed higher mean values for seed cotton yield than rest of the populations while the inter-specific cross had higher range of mean values for this character suggesting that selection would be effective for seed cotton yield/plant in the selective intermated population of both the crosses and for ginning out turn in the inter-specific cross only.

The F_4 population raised through self pollination from the intra-specific cross (MDL 2556 × PA 141) exhibited high range of mean values for seed cotton yield and number of bolls/plant while inter-specific cross (MDL 2452 × Jaydhar) had high mean values for seed cotton yield, number of bolls/plant and ginning out turn.

Self pollinated population of the intra-*arboreum* cross MDL 2556 × PA 141 showed significant increase in variability for seed cotton yield/plant and number of bolls/plant when the estimates of variance were compared using the F test. The estimates of CV were in the order of self > selective intermating > open for these two characters. The variability estimates for lint index indicated significant increase in open pollinated population while both self and open pollinated populations had significantly higher variability for seed index as compared to selective intermating derived population. The magnitude of CV was in the order of open > selective intermating > self for lint index and open > self > selective intermating for seed index. However in the inter-specific cross MDL 2452 × Jaydhar significantly higher variability was observed for halolength in open pollinated population followed by selective intermated and self pollinated populations. The estimates of C.V. were in the order of open > selective intermating > self. The estimates of variance for ginning out turn were significantly higher in selective intermated derived population as compared to the other two populations. The order of C.V. for this trait was selective intermating > self > open.

Population derived from self pollination in MDL 2556 × PA 141 showed significantly higher means over intermated population as ascertained by 't' test. However, significantly higher means in self pollinated population were observed over open pollinated and selective intermating populations for seed cotton yield/plant and over only selective intermating population for number of bolls/plant, while open and selective intermated populations exhibited similar trend for halo length over self pollinated population of the same cross.

A joint consideration of both F & t tests in the two crosses revealed that improvement of halo length will be effective in populations advanced through open and selective intermating.

The estimates of C.V. (Table 2) showed little differences for most of the characters among the three populations. The intra-specific cross MDL 2556 × PA 141 showed reduced C.V. in selectively intermated derived population over self pollinated for the characters *viz.*, seed cotton yield/plant, number of bolls/plant, boll weight, halo length and ginning out turn. Under these conditions one might expect predominant coupling phase linkages and a reduction in magnitude of variances. On the contrary reverse trend was observed in MDL 2452 × Jaydhar, an inter-specific cross in which the estimates of C.V. were high in selective intermating than self pollinated population for all the characters except boll weight.

Association among yield and its components: The significant phenotypic correlation coefficients among yield and other components are given in Table 3. Correlations involving seed cotton yield are of primary importance. The components of yield that are frequently correlated with yield are boll weight and boll number. In both the intra and inter-specific crosses yield is positively correlated with number of bolls per plant in all the three populations and boll weight in selective intermated population of MDL 2452 × Jaydhar.

One of the major objectives of this study was to generate variability so as to combine yield with good plant type traits. In the interspecific cross MDL 2452

Table 2. Estimates of some population parameters in F_4 generation of an intra-specific MDL 2556 × PA 141 and an inter-specific MDL 2452 × Jaydhar crosses advanced by three mating systems

Mating systems/ Characters		Selective intermating			Open pollinated			Self pollinated		
		Mean	Range	CV%	Mean	Range	CV%	Mean	Range	CV%
Number of bolls/plant	Intra	13.38±0.96	8.00-20.00	26.0	12.69±0.81	10.00-18.00	23.1	12.54±2.08	5.00-35.00	59.8
	Inter	19.92±1.36	10.00-38.00	34.2	17.44±1.44	7.00-32.00	41.2	23.16±1.27	12.00-36.00	27.4
Boll weight (g)	Intra	2.33±0.07	2.00-2.81	11.0	2.28±0.09	1.88-2.86	13.9	2.22±0.08	1.90-2.64	12.2
	Inter	2.50±0.04	2.08-2.97	8.0	2.60±0.05	1.98-3.07	10.1	2.50±0.04	2.09-2.80	8.5
Seed cotton yield/plant(g)	Intra	31.07±2.48	20.00-56.20	29.9	28.78±1.84	18.80-40.40	23.1	27.69±4.51	11.60-73.60	58.7
	Inter	50.14±3.77	23.80-96.00	37.6	45.50±3.96	20.40-87.00	43.5	57.84±3.39	28.80-89.20	29.3
Seed index (g)	Intra	6.16±0.06	5.80-6.60	3.6	6.17± 0.19	4.60-7.20	11.1	6.11±0.15	5.20-7.20	8.6
	Inter	5.92±0.09	5.20-6.60	7.5	5.80±0.09	5.20-6.60	7.8	5.78±0.08	5.00-6.60	7.1
Lint index (g)	Intra	3.03±0.07	2.60-3.40	8.7	3.22±0.12	2.40-3.80	13.3	3.28±0.06	3.00-3.80	6.8
	Inter	4.06±0.07	3.40-4.60	8.1	4.06±0.06	3.60-4.40	6.9	4.14±0.05	3.40-4.60	6.0
Halo length (mm)	Intra	24.05±0.24	22.80-25.40	3.7	24.02±0.21	22.60-25.10	3.1	23.95±0.31	22.20-25.50	4.6
	Inter	21.84±0.20	20.00-25.00	4.5	21.92±0.29	20.40-26.70	6.6	21.04±0.13	20.00-22.50	3.1
Ginning out turn (%)	Intra	34.87±0.52	31.40-37.90	5.4	34.35±0.82	26.76-38.75	8.6	33.48±0.83	25.00-36.52	8.9
	Inter	42.15±0.80	35.80-55.88	9.4	42.16±0.44	37.14-46.84	5.2	43.35±0.46	37.66-48.62	5.3

× Jaydhar the non-significant correlation of boll weight with yield in both self and open pollinated populations was changed to significant and positive association in the selective intermated population. On the contrary non significant association of ginning out turn with yield in self and open pollinated populations was changed to negatively significant and non-significant in the selective intermated population of both intra (MDL 2556 × PA 141) and inter-specific crosses (MDL 2452 × Jaydhar) respectively which is an undesirable one. The negative association of halo length with yield in self pollinated population was changed to positive though non-significant in open and selective intermated populations of the intra-specific cross, (MDL 2556 × PA 141) which shows desirable trend. Further, negative association of seed index with yield in self pollinated population of the two crosses was changed to positive and non-significant in selective intermated population. Similar results for other characters were reported by Meredith and Bridge (3) and Tyagi (4) in the open pollinated population of *G. hirsutum* cotton.

Population derived through all the three mating systems in both the crosses had seed cotton yield positively correlated with number of bolls while most of the other characters exhibited correlation with each other in selective intermated population only. However, the self pollinated population in the intra-specific cross indicated high genotypic association for these two traits followed by selective intermated and open pollinated populations. On the contrary both the selective intermated and open pollinated populations in the inter-specific cross exhibited high correlation coefficients as compared to self pollinated population.

The significant changes in associations observed in populations of the intra- and inter-specific crosses of diploid cotton advanced to F_4 generation by three different mating systems are presented in Table 3.

In the intra-specific cross MDL 2556 × PA 141 out of the 21 character associations 14 showed some changes in the populations raised through three mating systems (Table 3). The change in correlation coefficients can be obtained if the initial linkages in a predominant repulsion phase are broken down. The character pairs (1,7), (3,7) and (6,7) which were positively non-significant in open and self pollinated populations were changed to negatively significant in selectively intermated derived population while that of (2,6) showed positively significant association in selective intermated population. The correlation of lint index with ginning out turn was found to be positively significant in open pollinated population and seed index with ginning out turn was negatively significant in selective intermated population. The non-significant positive associations in both self and open pollinated derived populations of the cross MDL 2452 × Jaydhar for the character pairs (2,3),(2,4),(4,6) and (5,7) showed significant association in selective intermated population, the character pair (2,5) exhibited positive and significant association in both selective intermated and open pollinated populations. The correlation of seed index with ginning out turn which was found to be negatively significant in self pollinated population was changed to negatively non significant in open and self pollinated populations.

Pattern of transgressive segregation: In diploid cottons transgressive breeding could be a better alternative given its low genetic variability. In the present study transgressive segregants were recovered and which were depicted using frequency distribution curves. Line graphs and curves were drawn by first grouping the observations into classes with class values as twice the standard deviation estimated from parental variance. The frequencies were plotted against the class values using Harvard graphics.

All the three populations in the intra-*arboreum* cross had irregular curves in case of number of bolls/plant, seed cotton yield/plant, seed index, lint index, halo length and ginning out turn which could be either due to isodirectional dominance or blurring effect of the environment or both. However, seed cotton yield/plant had normal curve in open pollinated population while number of bolls/plant and lint index also exhibited normal curve in respect of self pollinated population indicating the possible role of epistatis and environmental influences.

In the intra-specific cross (MDL 2556 × PA 141) the frequency curve for ginning out turn got skewed towards the side of the better parent in the order of IM followed by OP and SP for seed cotton yield/plant, number of bolls/plant and boll weight and OP followed by SP and IM for seed index. The frequency of recovering transgressive segregants beyond the limit of desirable parent is almost negligible incase of halo length, ginning out turn and nil for lint index. Both selective intermating and open pollinated populations showed recovery of transgressive segregants beyond the limit of better parent for seed cotton yield/plant, number of bolls/plant and boll weight suggesting the operation of strong gametic/zygotic selection for these traits. Lint index had thrown transgressive segregants towards the side of undesirable parent in all the three populations. On the contrary Ahmed and Mehra (5) suggested the superiority of selective intermating over the other two mating systems to obtain a wider range of yield transgressants in F_4 generation of an intra-*barbadense* cross.

In selective intermated derived population of the inter-specific cross (MDL 2452 × Jaydhar) all the characters (except seed index) *viz.*, number of bolls/plant, boll weight, seed cotton yield/plant, lint index, halo length and ginning out turn had shown normal curves indicating the possible role of epistatis and

Table 3. Significant associations and types of changes in associations observed in the populations of an intra-specific (MDL 2556 × PA 141) cross* and an inter-specific (MDL 2452 × Jaydhar) cross advanced to F_4 generation by three different mating systems

Character pair	a) Intra-specific cross (MDL 2556 × PA 141)			b) Inter-specific cross (MDL 2452 × Jaydhar)		
	Population-1 (self pollination)	Population-2 (open pollination)	Population-3 (selective intermating)	Population-1 (self pollination)	Population-2 (open pollination)	Population-3 (selective intermating)
	r - value	r - value	r - value	r - value	r - value	r - value
1,2	−0.082	−0.198	−0.086	0.087	0.143	0.325
1,3	0.982*	0.851*	0.899*	0.956*	0.981*	0.982*
1,4	−0.412	−0.389	0.215	−0.075	0.188	0.218
1,5	0.181	0.217	0.068	0.180	0.136	0.176
1,6	−0.052	−0.185	0.078	0.100	0.155	0.117
1,7	0.319	0.220	−0.546*	0.163	0.203	−0.222
2,3	0.092	0.342	0.351	0.366	0.320	0.489*
2,4	0.325	0.506	0.113	0.204	0.265	0.465*
2,5	0.136	0.529	−0.052	0.301	0.397*	0.521*
2,6	0.053	0.419	0.644*	−0.125	0.217	−0.112
2,7	0.058	0.249	−0.458	−0.216	0.224	0.098
3,4	−0.370	−0.076	0.257	−0.005	0.230	0.279
3,5	0.209	0.469	0.044	0.237	0.189	0.286
3,6	−0.015	0.058	0.335	0.054	0.199	0.081
3,7	0.346	0.317	−0.687*	0.084	0.231	−0.174
4,5	0.235	0.436	0.394	0.121	0.674*	0.264
4,6	−0.070	0.412	0.133	0.195	0.112	0.610*
4,7	−0.187	−0.085	−0.293	−0.515*	−0.017	−0.234
5,6	−0.116	0.463	−0.140	0.067	0.005	−0.069
5,7	−0.073	0.595*	0.223	0.294	0.317	+0.428*
6,7	0.413	0.332	−0.691*	−0.261	−0.011	−0.298

*Significant correlation at P = 0.05

environmental influences, while the curve in seed index was skewed which may be due to dominance or blurring effect of environment (or) both. The frequency curve got skewed towards the side of the better parent in the order of SP followed by IM and OP for seed cotton yield per plant and number of bolls/plant and OP followed by SP and IM for boll weight and ginning out turn and IM followed by OP and SP in respect of halo length, indicating the potential of all the three systems in obtaining superior recombinants for various characters. Surprisingly, both self and open pollinated systems showed recovery of individuals only beyond the better parental range, suggesting the operation of strong gametic/zygotic selection for the respective traits. Contrary to this seed index showed transgressive segregants beyond the limit of undesirable parent.

The results of the present investigation clearly suggest that for simultaneous improvement of yield and yield contributing characters along with halo length and ginning out turn progenies of the interspecific cross advanced through self and open pollination would provide wider scope for the recovery of transgressive segregants as against the distinct advantages offered by selective intermating in the intra specific cross.

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