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IMPACT OF MATING SYSTEMS ON GENETIC VARIABILITY IN A CROSS OF *GOSSYPIUM BARBADENSE*

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ABSTRACT

The impact of the mating systems in generation of variability in an intra *barbadense* cross 10-98-P_1 × 11-181- was studied in F_4 generation. A variable response was observed specific to character and the mating system used to advance the generations. Linkage disequilibrium could be a serious factor causing reduced genetic variability observed for some of the traits in the populations advanced through random intermating and open pollination as compared to self pollination.

Significant changes in character association were observed in F_4 populations of the *barbadense* cross 10-98-P_1 × 11-18-P_2 advanced following three mating systems. Such changes are expected if predominantly repulsion phase linkages are broken down due to recombination.

The selective intermating system offered good opportunity to release a wider range of yield transgressants over the other two mating systems. However the study also indicated that in the populations linkage disequilibrium is still a contributing factor to cause difficulties in improving yield with both high boll number and boll weight.

Key Words : *Gossypium barbadense*, mating systems, linkage disequilibrium transgressive segregation.

In India early unsuccessful attempts to cultivate *Gossypium barbadense* in the northern parts was mainly due to utilisation of limited genetic variability. Given the predominance of self pollination in *G. barbadense*, there is little chance for new recombinants to occur after the F_2 generation [1]. 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 random intermating has been suggested by Hanson [2] and by Miller and Rawling [3]. The present study was undertaken to evaluate the nature of genetic variability generated in three derived populations of an intra

*Present address: Deptt. of Health & Family Welfare, Dispur, Guwahati *barbadense* 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 the mating systems in dissipation of undesirable linkages and changes in character associations. The behaviour of transgressive segregations observed following three mating system has also been examined.

MATERIALS AND METHODS

In *G. barbadense*, F_3 single plants from a cross involving dwarf and low yielding parent 10-98-P1 and tall moderate yielding parent (11-181-P2) (Table 1) were selected.

Table 1. Agronomic characteristics of parents of *Gossypium barbadense* cross 10-98-P_1 × 11-181-P_2

Character	P_1 : 10-98-P_1	P_2 : 11-181-P_2
Plant height (cm)	72.80 ± 2.23	104.40 ± 4.6
First fruiting node number	6.80 ± 0.58	9.50 ± 0.9
Monopodia	0.40 ± 0.25	0.80 ± 0.4
Sympodia	14.20 ± 1.16	18.60 ± 1.0
Boll number	13.20 ± 0.58	21.80 ± 2.0
Boll weight (g)	2.60 ± 0.18	3.00 ± 0.2
Economic yield (g)	12.70 ± 1.18	17.10 ± 1.0

The selected plants were subjected to three different mating systems viz., selective intermating, open (random) pollination, self pollination and advanced to F_4 in a progeny row trial with three replications during kharif season of 1993 at I.A.R.I. farm, New Delhi. The three resulting populations 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.

RESULTS AND DISCUSSION

The study of genetic parameters of means and variability (Table 2) revealed that for both boll weight and seed index, population means and c. v. values of similar magnitude were exhibited by all the three populations, though for boll weight wider ranges were observed in selective inter mating and open pollinated populations in comparison to self pollinated population.

Table 2. Estimates of some population parameters in F_4 generation of an intra *barbadense* 10-98-P_1 × 11-18-P_2 cross advanced by three mating systems

S. no.	Mating systems / Characters	Selective intermating			Open pollinated			Self pollinated		
		mean	range	CV (%)	mean	range	CV (%)	mean	range	CV (%)
1	Plant height (cm)	76.78 ± 1.64	42.00 - 112.00	20.0	80.73 ± 4.92	58.00 - 120.00	23.7	80.18 ± 3.91	57.00 - 108.00	19.5
2	First fruiting node number	6.66 ± 0.21	3.00 - 13.00	29.2	6.87 ± 0.31	5.00 - 9.00	17.3	7.94 ± 0.62	5.00 - 13.00	31.0
3	Monopodia	1.115 ± 0.13	0.00 - 4.00	104.6	1.33 ± 0.29	0.00 - 3.00	83.7	1.06 ± 0.69	0.00 - 3.00	105.9
4	Sympodia	12.92 ± 0.46	6.00 - 25.00	32.8	14.40 ± 0.88	10.00 - 19.00	23.7	12.56 ± 1.21	7.00 - 24.00	38.6
5	Boll number	8.17 ± 0.38	3.00 - 20.00	43.0	6.33 ± 0.74	1.00 - 13.00	45.0	9.50 ± 0.89	3.00 - 17.00	37.5
6	Boll weight@(g)	6.86 ± 0.18	1.20 - 13.10	24.2	6.42 ± 0.34	3.50 - 9.00	20.7	6.36 ± 0.31	3.80 - 7.80	19.2
7	Economic yield(g)	18.08 ± 0.84	4.20 - 41.30	43.5	12.93 ± 1.52	3.00 - 26.00	45.6	19.14 ± 1.90	3.80 - 31.60	41.7
8	Biological yield (g)	85.89 ± 4.43	22.10 - 191.40	48.1	79.91 ± 11.83	40.20 - 218.10	57.3	80.78 ± 8.59	38.20 - 161.00	42.6
9	Harvest index (%)	23.14 ± 0.90	7.46 - 44.35	36.2	18.80 ± 2.53	4.86 - 35.96	52.1	25.18 ± 2.55	8.65 - 47.09	40.5
10	Seed index	9.45 ± 0.15	5.37 - 12.77	14.6	9.74 ± 0.38	7.05 - 12.66	15.0	9.19 ± 0.36	6.53 - 12.00	15.5
11	Ginning percentage	36.55 ± 0.88	13.18 - 58.54	22.5	31.85 ± 1.57	18.18 - 41.46	19.1	33.32 ± 1.30	18.92 - 39.06	15.6
12	Lint index	5.64 ± 0.21	1.38 - 11.47	35.1	4.62 ± 0.34	2.12 - 7.33	28.4	4.70 ± 0.32	2.42 - 6.90	27.4

@Three bolls weight.

The population derived through selective intermating showed higher mean values for biological yield, ginning percentage and lint index and lowest mean values for plant height and first fruiting node in comparision to other two populations. Selective intermating population also showed high range for plant height, first fruiting node number, monopodia, sympodia, boll number, boll weight, economic yield, seed index, ginning percentage and lint index. This indicated that selection for monopodia, boll weight, seed index, ginning percentage and lint index would be effective in this population.

The F_4 population raised through self pollination exhibited high mean values for first fruiting node number, boll number, economic yield and harvest index and it also showed high range for harvest index.

Using F-test for comparing the variance estimates, significant increase was noted in variability for first fruiting node number in self pollinated population. The estimates of c.v. were in the order of : Open < Selective intermating < Self. The variability for boll weight, ginning percent and lint index was significantly higher in selective intermating derived population. The order of magnitude of c.v. in these three characters were Selective>Open>Self.

Using t-test for comparison of means in the three populations, significantly higher means in comparison to other two populations were observed for first fruiting node number and boll number in self pollinated population, for economic yield in populations derived from selective intermating and self pollination over open pollinated population and for ginning percentage in selective intermating derived population as compared to the other two populations.

A joint consideration of both F-and t-tests revealed that improvement for first fruiting node number will be effective in population advanced through self pollination and for ginning percentage further selection could be effective in population derived from selective intermating.

Miller and Rawlings [3] and Meredith and Bridge [4] attributed differences between F_3 progenies of original population and intermated population particularly of yield to selection which may have inadvertently entered into their experiment. This possibility cannot be ruled out in the present study also. Further, Miller and Rawlings [3] supposed that the more vigorous and higher yielding plants produced more pollen at flowering time and thus contributed more than the proportional share of gametes to the succeeding generation and changes for characters other than yield could be accounted for by correlated responses. However, in the present material the observed changes in means can also be attributed to: i) differences in population size resulting in genetic drift, ii) epistasis, besides correlated response due to selection.

An F_2 population is not generally in linkage equilibrium. Hanson [2] has shown that genetic variances may vary considerably from those expected for populations in genetic equilibrium. Crosses with a predominant coupling phase linkages would be expected to have reduced genetic variances upon intermating. Genetic variance would be expected to increase for those crosses with a predominant repulsion phase linkage. While significant changes in genetic variances indicate the presence of linkage, non- significance does not necessarily exclude absence of such linkages.

The estimates of c.v. (Table 2) show little differences for most of the characters among three populations. Sympodia, harvest index and seed index showed reduced c.v. in derived inter-mating population over self pollination derived population. Under these conditions, one might expect predominant coupling phase linkages and a reduction in magnitude of genetic variances. As more selection pressure is applied, the variance is likely to get further reduced in a population with predominately coupling phase linkages. This inference is based on the assumption that considerable linkage disequilibrium exists in F_3 also and differences in population size do seriously bring about changes.

The extent to which linkage blocks are broken and genetic recombination occurs is of critical interest to the plant breeder since the success of his breeding program depends upon obtaining desirable character recombinations.

Association among yield and its component

The significant phenotypic correlation coefficients among yield and other characters are given in Table 3. Correlations involving seed cotton yield are of primary importance. The components of yield that are most frequently correlated with yield are boll weight, boll number and harvest index.

One of the major objective(s) of this study was to generate variability so as to combine yield with good plant type traits. This was realised to some extent. The non-significant correlation of plant height with yield was changed to significant positive association in the intermating population (Table 4). Similar was the case for biological yield. Boll weight and yield showed little association in open pollinated system but in selfed and selective intermating populations, this association was significant and positive. However, for monopodia selective intermating showed an establishment of positive association with yield which is not desirable from plant type point of view. Further the negative correlation of sympodia, seed index, ginning percentage and lint index with yield in open pollinated population was changed to positive though non- significant in selective inter mating population. Similar results for other characters were reported by Miller and Rawlings [3], Meredith and Bridge [4] and Tyagi [5].

Table 3. Significant associations observed among yield and its components in F_4 populations advanced by three different mating systems in *Gossypium barbadense* cross 10-98-P_1 × 11-181-P_2

Selective intermating		Open pollination		Self pollination	
Character pair	r-value	Character pair	r-value	Character pair	r value
1, 4	0.585	1, 4	0.852	1, 4	0.609
1, 6	0.231	1, 8	0.778	1, 8	0.900
1, 7	0.261	1, 9	–0.607	5, 7	0.900
1, 8	0.462	1, 10	0.522	5, 9	0.728
1, 9	–0.335	3, 8	0.509	5, 12	0.538
2, 7	–0.208	3, 10	0.629	6, 7	0.629
3, 8	0.257	4, 8	0.612	10, 12	0.585
3, 9	–0.309	4, 9	–0.637	11, 12	0.831
4, 6	0.249	5, 7	0.822		
5, 7	0.806	5, 9	0.598		
5, 8	0.413	5, 11	–0.576		
5, 9	0.336	5, 12	–0.624		
6, 7	0.339	6, 12	0.589		
6, 10	0.234	7, 9	0.743		
6, 12	0.219	8, 9	–0.502		
7, 8	0.510	10, 12	0.509		
7, 9	0.326	11, 12	0.802		
8, 9	–0.481				
8, 10	–0.335				
9, 10	0.339				
10, 11	–0.233				
11, 12	0.888				

Numbers in character pairs correspond to serial numbers against characters in Table 2

For most traits that had high genotypic associations in original (selfed or open pollinated) population, correlations were found to be lowered in the intermated population, e.g. in case of boll number and boll weight with economic yield (Table 3). Similar results were reported by Miller and Rawlings [3] and Meredith and Bridge [4].

The significant changes in associations observed in populations of *G. barbadense* cross 10-98-P1 × 11-181-P2 advanced to F_4 generation by three different mating systems are presented in Table 4.

Table 4. The changes in associations of yield with its components in populations advanced through three different mating systems on our intra *barbadense* cross

Population	Yield with								
	Plant height	First fruiting node number	Mono-podia	Sym-podia	Boll weight	Biological yield	Seed index	Ginning percentage	Lint index
Self pollinated	+ns	−ns	+ns	+ns	+s	+ns	+ns	+ns	+ns
Open pollinated	−ns	+ns	−ns	−ns	+ns	+ns	−ns	−ns	−ns
Selective intermated	+s	−ns	+ns	+ns	+s	+s	−ns	+ns	+ns

s : Significant correlation at P = 0.05; ns = nonsignificant at P = 0.05
+ : Positive correlation; − : negative correlation

As many as 24 character associations, out of a possible (Table 5) 66 showed some changes in the populations raised through three mating systems. The change in correlation coefficients can be obtained if the initial linkages in a predominant repulsion phase are broken down [6]. The character pairs (1, 6), (1, 7), (4, 6), (5, 8), (6, 10), (7, 8), (9, 10), (2, 7), (3, 9), (8, 10) and (10, 11) which were non- significant in both self and open pollinated derived populations, showed significance in selective intermating derived population. The character pairs (3, 8), (6, 12), (7, 9) and (1, 9), (8, 9) also showed positive and negative significance respectively only in selective intermating and open pollinated derived population. The character pair boll weight and economic yield (6, 7) exhibited positive and significant association in both selective intermating and self pollinated derived population.

The character pairs (1, 10), (3, 10), (4, 8), (4, 9), and (5, 11) which were uncorrelated in selective intermating and self pollinated derived populations were found to be significantly associated in open pollinated population. The association of seed index and lint index was found to be positively significant in both selective intermating and self pollinated derived population. The correlation of boll number and lint index was found to be positively significant in self pollinated population but it changed to negatively significant in open pollinated population.

Table 5. Types of changes in associations observed in the populations of *Gossypium barbadense* cross 10-98-P_1 × 11-181-P_2 advanced to F_4 generation by three different mating systems

Character pair	Population-1 (self pollination)	Population-2 (open pollination)	Population-3 (selective intermating)
1, 6	ns	ns	+s
1, 7	ns	ns	+s
1, 9	ns	–s	–s
1, 10	ns	+s	ns
2, 7	ns	ns	–s
3, 8	ns	+s	+s
3, 9	ns	ns	–s
3, 10	ns	+s	ns
4, 6	ns	ns	+s
4, 8	ns	+s	ns
4, 9	ns	+s	ns
5, 8	ns	ns	+s
5, 11	ns	–s	ns
5, 12	+s	–s	ns
6, 7	+s	ns	+s
6, 10	ns	ns	+s
6, 12	ns	+s	+s
7, 8	ns	ns	+s
7, 9	ns	+s	+s
8, 9	ns	–s	–s
8, 10	ns	ns	–s
9, 10	ns	ns	+s
10, 11	ns	ns	–s
10, 12	+s	+s	ns

+s : Positively significant; –s: negatively significant; ns: not significant

Transgressive segregation

The transgressive breeding seems a better alternative in *Gossypium barbadense,* given its low genetic variability and its consecutive adaptability problems in north

India. In the study, the transgressive segregants were studied using frequency distribution curves.

Line graphs and curves were prepared by first grouping the observations into classes with class values as twice the standard deviation estimated from parental variances. The frequencies were plotted against the class values using Harvard graphics.

In selective intermating derived population plant height, first fruiting node number, boll weight, harvest index, seed index, ginning percentage and lint index followed normal curves indicating the possible role of epistasis and environmental influences, whereas the curves in case of monopodia, sympodia, boll number, biological yield and economic yield were skewed which may be either due to isodirectional dominance or blurring effect of environment or both.

For economic yield, the frequency curve got skewed towards the side of the better parent in the population raised through selective inter mating (Fig. 1) indicating the potential of this mating system in obtaining superior recombinants. Among yield components, only boll weight showed transgression beyond the better parent in all the three systems (Fig. 2). Surprisingly, both self and open pollinated systems showed recovery of individuals only beyond the better parental range, suggesting operation of strong gametic/zygotic selection for this trait. Contrary to this, monopodia (Fig. 3) showed transgressants beyond the limit of undesirable parent though the frequency of recombinants was more towards desirable parent (parent with zero monopodia). However, this is understandable as the number of monopodia cannot be less than zero.

For plant height, in all three mating systems more or less maximum frequency of transgressants was observed towards the side of lower parent. Generally medium plant height was desirable from crop improvement point of view but dwarf plant types with high harvest index and seed cotton yield are much more useful. Nearly equidistant range was observed independently for selective intermating and self pollinated systems.

In the present study, the differences in population sizes arose as a result of i) initially maximum attention given to selective intermating because of possible low rate of successful crossing and ii) carrying out of random and self pollination late in the season thus resulting in maximum flower drop which was further aggravated by inclement weather.

The study revealed that selective intermating offers good opportunity to release wider range of yield transgression (of course coupled with high frequency) over the

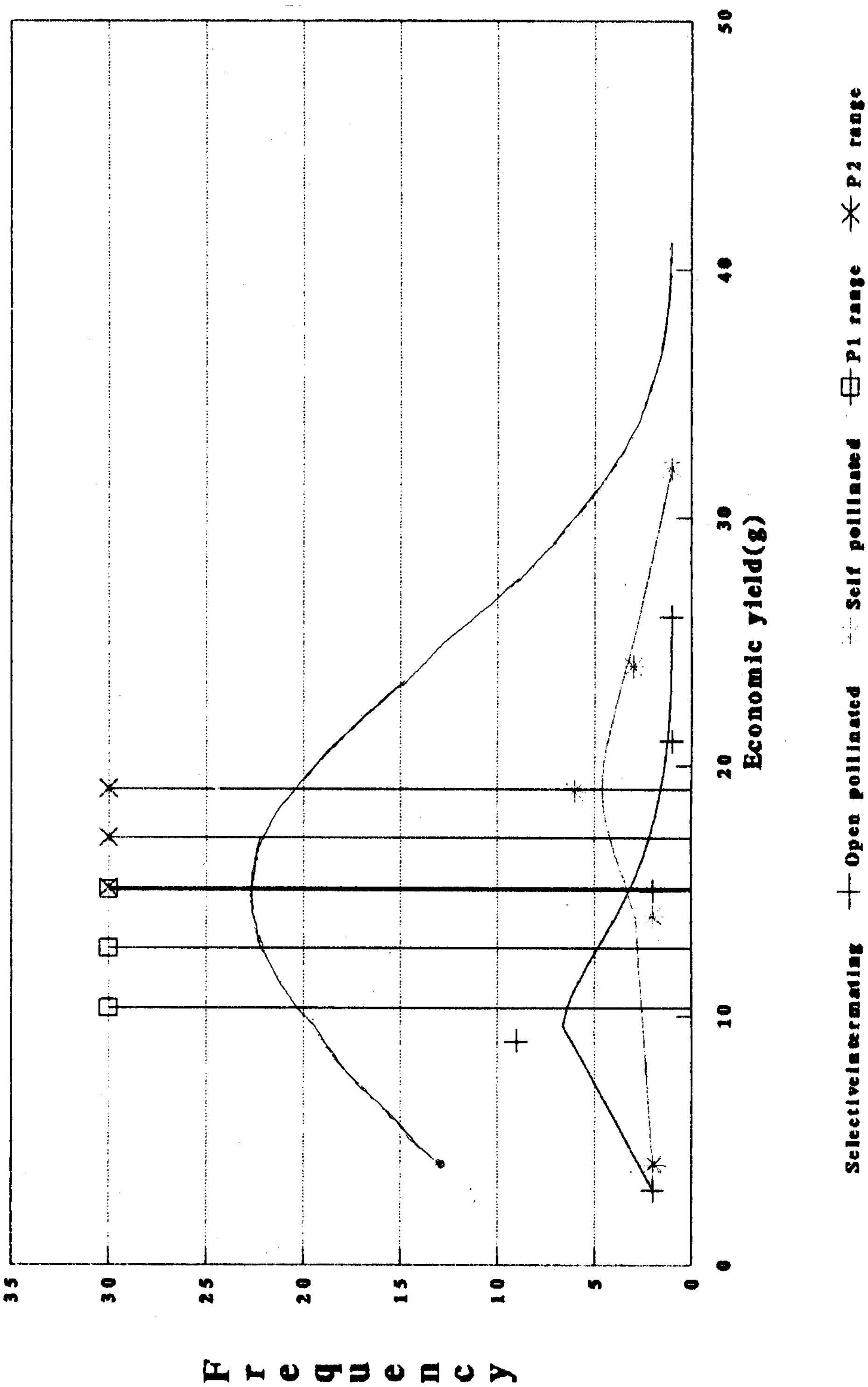

Fig. 1. Frequency distribution for F_4 population of *Gossypium barbadense* advanced from F_3 by three different mating systems

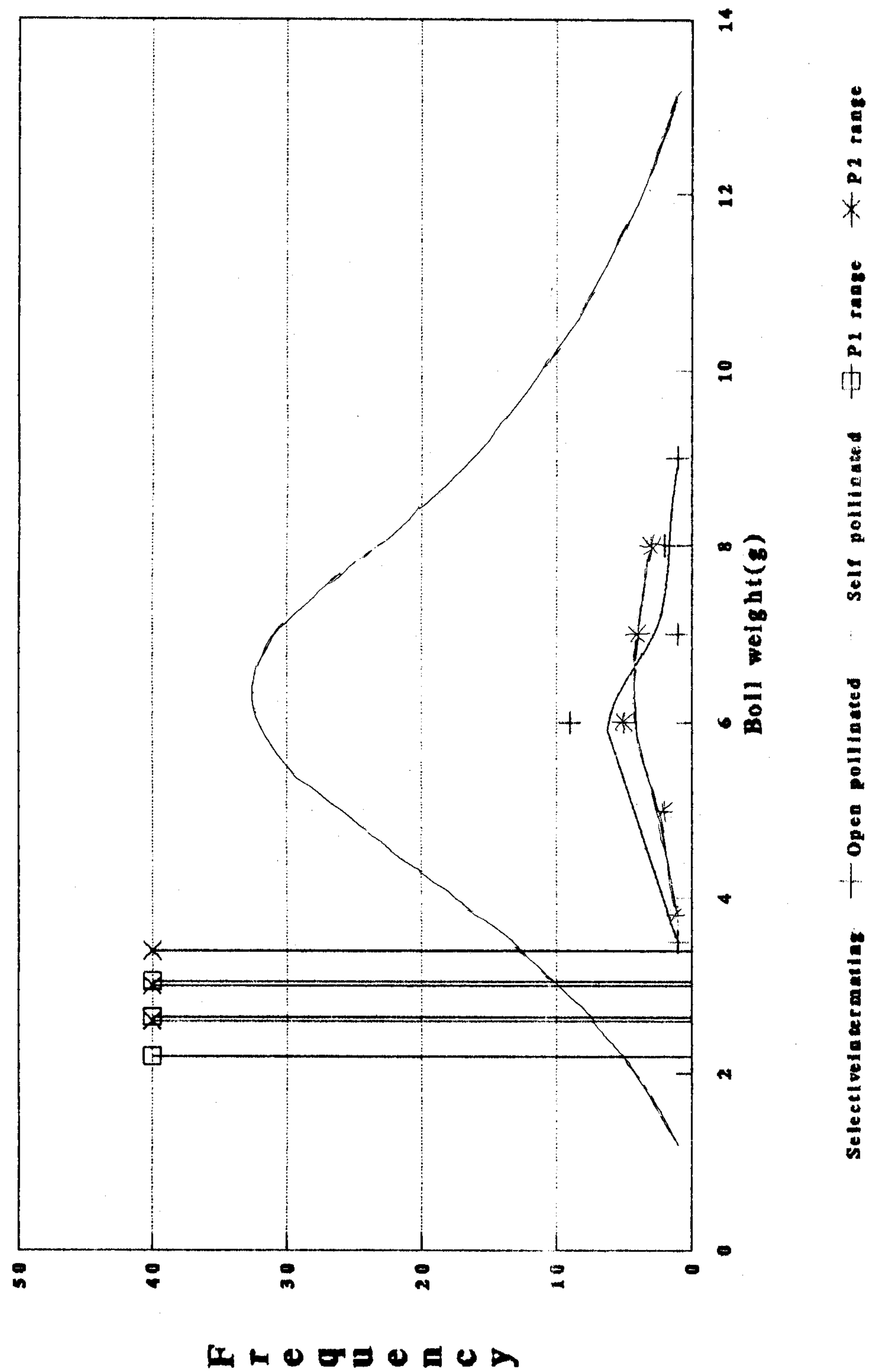

Fig. 2. Frequency distribution for F_4 population of *Gossypium barbadense* advanced from F_3 by three different mating systems

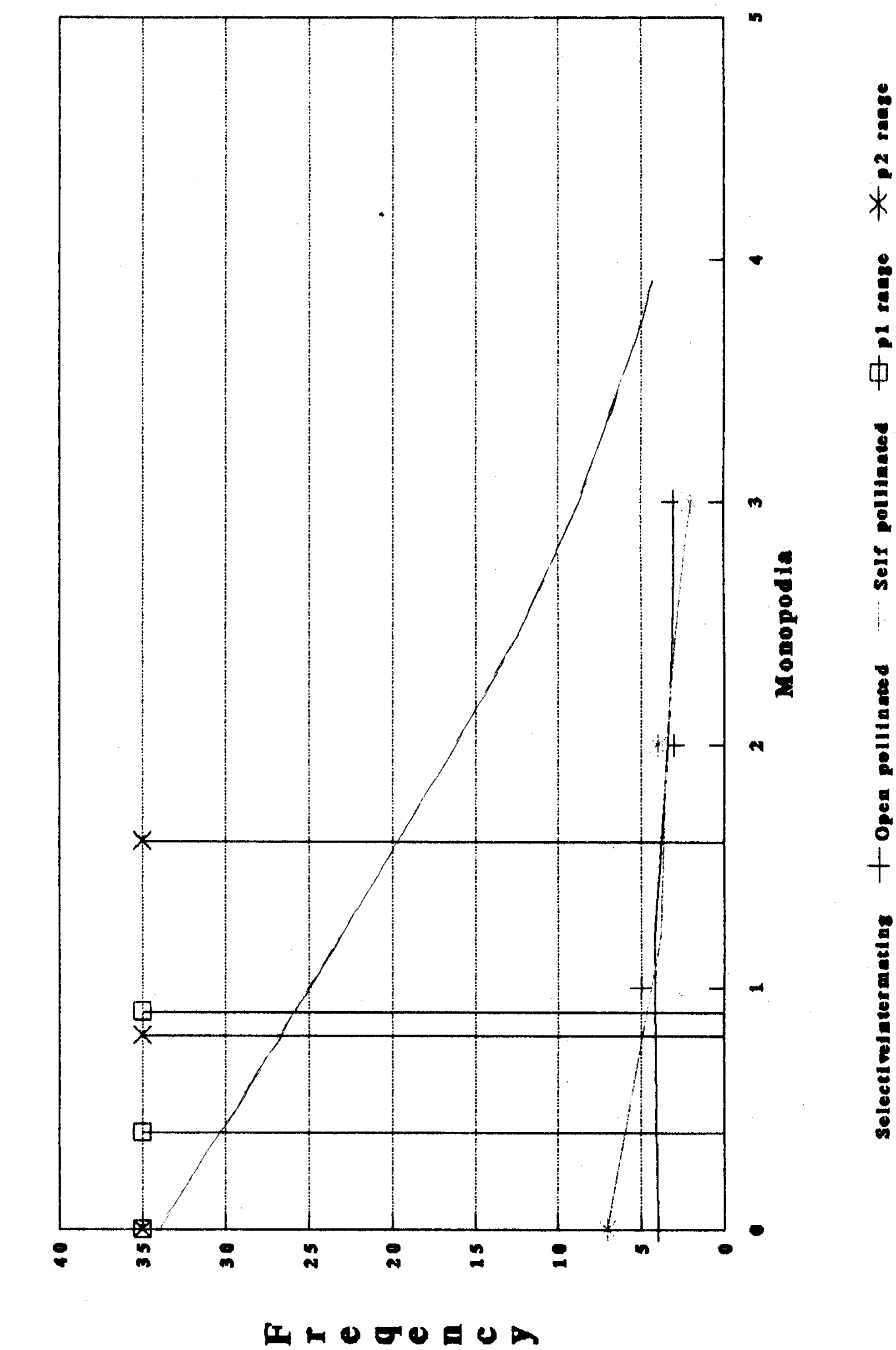

Fig. 3. Frequency distribution for F_4 population of *Gossypium barbadense* advanced from F_3 by three different mating systems

other systems. Comparison of yield recombinants indicated that although magnitude wise positive transgressants were more in selective intermating but per cent wise these were higher in self pollinated system followed by selective intermating. All positive yield transgressants were also positive transgressants for boll weight but on the contrary all the three systems did not give rise to transgressants for boll number. This study also indicated that in this population linkage disequilibrium is still a contributing factor to cause difficulties in improving yield with both high boll number and boll weight.

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