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EVALUATION OF HYBRIDS OBTAINED FROM CYTOPLASMIC MALE-STERILE LINES OF COTTON*

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Abstract

Eighteen hybrids obtained by pollinating two cytoplasmic male-sterile (CMS) lines viz., Tamcot-778 and Des-hams 16 with nine *hirsutum* pollinators were evaluated for heterosis estimates of hybrids and general combining ability values of pollinator parents with respect to days to maturity, weight of seedcotton, lintcotton and seeds per boll, number of seeds and motes per boll and ginning outurn percent.

Heterosis was considered as the percent increase or decrease in performance of a particular hybrid, with respect to a particular character, as estimated against the check variety. All the hybrids exhibited negative heterosis for all the characters except days to maturity and number of motes per boll. The positive heterosis for days to maturity and number of motes per boll was also considered as an undesirable attribute.

All the pollinators scored negative general combining ability values for all the characters considered and therefore it was concluded that these *hirsutum* pollinators used in this study are not suitable to be utilized further to produce our own desired CMS lines. The use of fertility restorer pollinators onto CMS lines has been suggested in continuing hybrid cotton breeding programme.

Introduction

In cotton, four methods of producing F_1 hybrid seed have been recognized, viz., hand pollination, natural cross pollination, chemical male-gametocides and the use of cytoplasmic male-sterile lines. Hand pollination is tedious, time consuming and expensive to be adapted commercially. Natural cross pollination is only possible where honey bee pollinators are abundant. It has been reported 2% in Pakistan, 35% in Egypt, 50% in Tennessee and 81% in Alabama, USA (Baluch, 1981). Sodium alpha-dichloro-isobutyrate (FW-450) as male-gametocide to induce male-sterility in cotton was first reported

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by Eaton (1957) besides other chemicals like Dalapon, maleic hydrazide (Meyer, *et al,* 1958) and TD-1123 (Olvey, Fisher & Patterson, 1981). Cytoplasmic controlled male-sterility in cotton was reported by Meyer & Meyer (1965). Virtually complete male-sterility resulted in plants with homozygous partially recessive gene in *anomalum* cyto-plasm. Reciprocal crosses of these plants with *hirsutum* (variety M8) produced highly fertile progenies if the cytoplasm was from *hirsutum*, and partially sterile progenies if the cytoplasm was from *anomalum.*

The findings of cytoplasmic-genetic male-sterility have paved a way to produce commercial hybrid cotton seed, and the biggest incentive for attempting production of hybrid cotton is, to take the advantage of the considerable heterosis which is already known to exist in the crop. Thus the selection of best combinations in terms of yield and quality, from cytoplasmic male-sterile lines in an open pollinated field or by manual crossing, depends upon the amount of hybrid vigour or heterosis by which the combina-tion excell their best yielding parent. Therefore, it is worthwhile to increase the yield per hectare by exploiting the hybrid vigour which is defined as percentage increase in yield of the hybrid over the better parent or over the mean of two parents. Utilization of hybrid vigour in cotton by growing first generation hybrids has long been reported by Kime & Tilley (1947), Loden & Richmond (1951), Simpson (1954), Baluch (1961), Miller & Lee (1964), Meredith & Bridge (1972), Thompson (1973), Davis (1974), Baker & Verhalen (1975), Choudhry, Khan & Khan (1978), Weaver (1979), Khan & Ali (1980), Ahmad & Channa (1981), Ahmad, Channa & Soomro (1981) and Soomro, Ahmad & Soomro (1982).

Exploitation of hybrid vigour and heterosis through the use of cytoplasmic male-sterile lines has been suggested by Meyer & Meyer (1965), Weaver (1968, 1969, 1971, 1978, 1979), El-Kadi & Weaver (1972), Davis (1979), Sheetz & Weaver (1980), Davis & Palomo (1980) and Palomo & Davis (1981).

The studies reported in this paper deal with the performance of F_1 hybrids obtained from cytoplasmic male-sterile lines of cotton when manually pollinated with non-restorer *hirsutum* pollinators with respect to seven quantitative characters. The object of the present investigation was to assess the general combining ability of the pollinator parents on one hand, in order to look into the possibility of producing our own desired A-lines through recurrent backcrossing and to estimate the amount of heterosis of different combinations obtained from cytoplasmic male-sterile lines in terms of yield and quality on the other hand and to isolate the outstanding ones.

Material and Methods

The material used in the present studies comprised of two cytoplasmic male-sterile (CMS) lines *(hirsutum* genome in *harknessii* cytoplasm) Tamcot-778 and Des-hams-16 and nine *hirsutum* pollinator varieties including local standard Qalandri. The

CMS parents were obtained through the courtesy of Prof. Dr. J. B. Weaver, Department of Agronomy, University of Georgia, Athens, Georgia, USA. *Hirsutum* pollinators were selected from the gene pool being maintained at the Cotton Research Institute Sakrand since its inception. Weaver (1981) has suggested skip-planting technique to sow these CMS lines alongwith *hirsutum* pollinators/fertility restorers for open pollination purposes. But since the quantity of seed of these CMS lines was quite limited and also due to very low bee activity at Tandojam, the CMS lines were hand-dibbled each in two lines, flanked by nine pollinators in order to manually pollinate the CMS parents. Sowing was done on 20th May 1981 keeping 15 cms plant-to-plant and 75 cms row-to-row distance in a plot of 80 ' x 20 ' at Botanical Garden of Department of Plant Breeding and Genetics, Sind Agriculture University, Tandojam. Recommended dose of fertilizer in the form of DAP (4 lbs per plot) during soaking dose and urea (6 lbs per plot) in two split doses viz., 2 lbs at the time of first irrigation (22-6-1982) and remaining 4 lbs at the time of flowering (24-7-1981), was also applied to the crop.

Hirsutum pollinator androeciums were hand brushed onto newly receptive CMS stigmas and then bagged. At the time of full boll opening, days to maturity were counted (from the crossing date) for each boll set obtained after hybridization. Other observations recorded for each boll set thus harvested were: weight of seedcotton per boll (in gms), weight of lintcotton per boll (in gms), weight of seeds per boll (in gms), number of seeds per boll, number of motes per boll and ginning outturn percentage.

Average performance of each entry (hybrid and parent) with respect to above mentioned metrical traits was represented in the form of arithmetic mean. Population variances and coefficients of variability were calculated after Sokal & Rohlf (1981) on the basis of number of bolls harvested per entry. Simple analysis of variance of the data to establish significant differences between the parents and the hybrids for all the quantitative characters was performed after Sokal & Rohlf (1981). Heterosis estimates of the hybrids were estimated as the percentage increase or decrease of a particular hybrid, for a particular character, as against the check variety (Qalandri in the present case) as suggested by Meredith & Bridge (1972). General combining ability values of the pollinator parents were calculated after Simmonds (1979). Simple correlation coefficients were also calculated between yield of seedcotton per boll and days to maturity, weight of lintcotton per boll, weight of seeds per boll, number of seeds per boll, number of motes per boll and ginning outturn percentage, respectively.

Results and Discussion

The average performance of hybrids together with their pollinator parents for seven quantiative characters considered in this study has been given in Table 1. The range of variation of each hybrid, its population variance and percent coefficient of variability for each of the quantitative character are given in Tables 2 and 3. On the basis of the mean performance, hybrid Des-hams-16 x M-106 took 49.8 days to mature while Des-hams-16 x 47/1-28/1 was the earliest. Hybrid Des-hams-16 x 9L34 ICCC yielded highest and Tamçot-778 x M-106 produced the lowest yield of seedcotton per boll. Highest lint per boll was produced by hybrid Des-hams-16 x W-1107 and hybrid Tamcot-778 x 47/1-28/1 produced the lowest lintcotton per boll. Theoretically highest seedcotton producing hybrid should have produced highest lintcotton but this depends upon the number of sound seeds and motes present in the boll and since the number of seeds were less in hybrid Des-hams-16 XWM-1107 its lint weight was higher than the hybrid Des-hams-16 x 9L 34 ICCC and consequently motes per boll were also less. In case of weight of seeds per boll, Des-hams 16 x 9L 34 ICCC ranked highest while Tamcot-778 x W-1107 was the lowest. For number of seeds per boll, 30.33 seeds per boll were produced by hybrid Des-hams-16 x 9L 34 ICCC while the lowest number belonged to Des-ham-16 x M-106. Highest motes per boll were obtained from hybrid Des-hams-16 x 47/1-28/1 while Tamcot-778 x Qalandri produced lowest. Finally for ginning outturn percentage (g.o.t), Tamcot-778 x CRIS-13/80 exhibited highest g.o.t. while Tamcot-778 x ST-3 was the lowest. If we compare the performance of these hybrids with their respective pollinators, all the hybrids proved to be late maturing, low yielding, with lower seed weight, lower number of seeds per boll and with less ginning outturn percentage. This implied therefore that the hybrids showed higher performance for undesirable characters while lower performance for desired attributes.

Tables 2 and 3 reveal the range of variability, population variance and coefficients of variability of these hybrids for all the characters under study. These estimates ascertain the magnitude of variation within population. The highest range of variablity for days to maturity was exhibited by hybrid Tamcot-778 x 47/1-28/a where 32 bolls set spent from 27 to 59 days to mature with 38.19 population variance and 14.77% coefficient of variability. But the highest CV of 23.02% was shown by hybrid Des-hams-16 x W-1107 with range of only 36 to 50 days and population variance of 98.01 implying that the coefficient of variability is not correlated with the range but it is positively correlated with the variance of population. Lower magnitude of range produced high CV because the two bolls set for this combination carried larger amount of deviation from the mean. Therefore it may be concluded that the hybrid with highest coefficient of variability and consequently with high population variance may be regarded as the unstable or inconsistent in its performance. Similarly hybrid Des-hams-16 x W-1107 showed the highest coefficient of variability and consequently the population variance for yield of seedcotton per boll, yield of lintcotton per boll, seed weight per boll and g.o.t., while hybrid Des-hams-16 x M-106 was the most unstable for number of seeds per boll and Tamcot-788 x ST-3 for motes per boll due to their high population variance and coefficient of variability.

The analysis of variance of the data in Table 1 was performed after Sokal & Rohlf (1981) in order to establish the differences between the parents and the hybrids and the results are presented in Table 4. In the analysis of variance, only mean-squares

Table 1. Average performance of hybrids obtained from crossing CMS lines with *hirsutum* pollinators with respect to seven quantitative characters.

Combination		Bolls obtained	Days to maturity per boll (gms)	Seed-cotton per boll (gms)	Lint-cotton per boll (gms)	Wt. of seeds boll	Seeds per boll	Motes per	g.o.t%
CMS, Tamcot–778									
Polli-	CRIS-1/80	17	42.24	1.58	0.49	1.09	20.71	1.94	31.52
nators	ST-3	33	42.05	1.28	0.29	0.98	19.86	5.23	21.93
	CRIS-13/80	28	42.86	1.47	0.46	1.02	21.75	5.61	31.71
	15A-292/4C	6	44.17	1.78	0.54	1.23	21.50	[illegible]	30.39
	W-1107	12	44.08	1.31	0.35	0.97	18.42	[illegible]	26.63
	47/1-28/1	32	41.88	1.07	0.25	0.70	20.69	3.56	24.31
	M106	30	42.33	0.98	0.32	0.70	16.87	3.37	29.01
	9L 34 ICCC	8	47.50	1.24	0.36	0.89	14.75	3.50	29.05
	Qallandri	25	44.64	1.27	0.38	0.85	18.24	1.92	28.60
CMS, DES-HAMS 16									
Polli-	CRIS-1/80	5	43.80	1.32	0.38	0.94	23.0	5.80	29.33
nators	ST-3	5	44.20	1.60	0.34	1.26	22.60	3.60	23.58
	CRIS-13/80	10	42.60	1.26	0.36	0.92	22.20	6.00	30.59
	15A-292/4C	12	41.17	1.38	0.42	0.96	22.23	6.54	29.97
	W-1107	2	43.00	1.85	0.55	1.30	21.00	2.50	25.63
	47/1-28/1	12	39.42	1.10	0.31	0.79	23.75	7.75	28.15
	M106	7	49.86	1.06	0.29	0.76	14.00	4.43	27.65
	9L 34/ICCC	3	49.67	2.23	0.50	1.73	30.33	7.0	21.94
	Qallandri	9	44.78	1.58	0.39	1.19	18.44	6.78	24.95

Table 2. Range (1st reading), variance (2nd reading) and per cent coefficient of variability (3rd reading) estimates of hybrids derived from Tamcot-778 cytoplasmic male-sterile line with nine *hisutum* pollinators for seven quantitative characters.

Pollinator	Days to maturity	Seedcotton per boll (gms)	Lintcotton per boll (gms)	Seed wt. per boll	Seeds per boll	Motes per boll	g.o.t%
CRIS-1/80	37 to 46	.07 to 3.7	.02 to 1	.05 to 2.7	6 to 33	0 to 8	25 to 40
	7.56	1.06	0.10	0.52	75.52	5.80	12.97
	6.51	64.98	63.76	66.47	41.95	124.23	11.43
ST-3	37 to 52	.3 to 3	.1 to .9	.2 to 2.1	9 to 30	0. to 30	15 to 33
	15.37	0.62	0.06	0.34	64.32	70.39	32.15
	9.33	61.89	81.9	59.42	40.38	160.42	25.84
CRIS-13/80	35 to 52	.15 to 3.5	.05 to 1	.1 to 2.6	9 to 31	0 to 28	20 to 40
	27.76	0.95	0.09	0.48	54.49	56.40	27.50
	12.30	65.99	65.22	68.63	33.93	133.87	16.53
15A-292/4C	40 to 47	.9 to 2.8	.25 to .9	.6 to 1.9	16 to 27	3 to 6	26 to 33
	6.97	0.69	0.29	0.32	20.34	1.58	7.23
	5.98	46.52	48.44	46.47	20.96	31.50	8.85
W-1107	35 to 51	.4 to 2.9	.1 to .7	.3 to 2.2	6 to 28	0 to 10	20 to 33
	26.42	0.85	0.05	0.50	59.14	12.72	21.25
	11.67	70.31	63.15	72.86	33.13	145.22	29.25
47/1 – 28/1	27 to 55	.2 to 2.4	.04 to .65	.15 to 1.7	10 to 33	0 to 25	14 to 40
	38.19	0.98	0.04	0.26	47.06	26.72	50.55
	14.77	93.59	79.45	72.86	33.13	145.22	29.25
M106	33 to 54	.15 to 3.6	.05 to 1	.1 to 2.6	5 to 29	0 to 21	25 to 33
	24.21	0.81	0.07	0.41	53.29	21.80	20.93
	11.63	91.83	84.37	91.42	43.27	138.58	15.58
9L 34/ICCC	38 to 55	.6 to 2.6	.2 to .7	.4 to 1.9	3 to 22	0 to 5	20 to 40
	44.22	0.72	0.05	0.41	33.64	2.56	34.57
	14.01	68.27	60.05	71.69	39.32	25.71	20.26
Qalandari	36 to 54	.3 to 3	.1 to .9	.2 to 2.1	4 to 37	0 to 9	20 to 40
	27.35	0.67	0.06	0.30	55.80	4.75	29.58
	11.71	64.57	65.78	64.54	40.97	113.54	19.02

Table 3. Range (1st reading), variance (2nd reading) and percent coefficient of variability (3rd reading) estimates of hybrids derived from DES-HAMS 16 cytoplasmic male-sterile line with nine *hirsutum* pollinators for seven quantitative characters.

Pollinator	Days to maturity	Seedcotton per boll (gms)	Lintcotton per boll (gms)	Seed wt. per boll	Seeds per boll	Motes per boll	g.o.t%
CRIS-1/80	36 to 51 42.24 14.83	.7 to 2.6 0.61 59.02	.2 to .6 0.37 53.93	.5 to 2 0.73 64.97	22 to 26 6.0 10.65	0 to 14 26.21 88.28	23 to 40 43.16 22.41
ST-3	37 to 54 37.70 13.89	.7 to 2.9 1.30 71.53	.2 to .6 0.04 57.33	.5 to 2.3 0.90 76.23	16 to 30 37.33 27.02	0 to 13 29.26 150.28	17 to 28 23.23 20.44
CRIS-13/80	37 to 54 37.58 14.39	.55 to 3.7 1.32 91.29	.6 to 1 0.08 81.20	.4 to 2.7 0.72 92.39	14 to 31 34.22 26.33	2 to 8 34.69 97.83	25 to 40 26.83 16.94
15A-292/4C	34 to 58 38.56 15.07	.6 to 3 0.69 59.86	.15 to .9 0.07 62.53	.4 to 2.2 0.34 60.37	13 to 28 26.32 23.10	0 to 28 73.44 131.04	23 to 39 17.98 14.15
W-1107	36 to 50 98.01 23.02	.5 to 3.2 3.65 103.20	.1 to 1 0.41 115.71	.4 to 2.2 0.41 97.91	19 to 23 8.01 13.47	0 to 5 12.53 141.60	20 to 31 63.20 31.02
47/1-28/1	30 to 50 23.91 12.40	.15 to 2.7 0.72 76.98	.05 to .7 0.05 75.52	.1 to 2 0.38 78.12	10 to 34 56.25 31.57	0 to 27 50.55 91.74	20 to 31 8.29 10.24
M016	37 to 59 81.18 18.07	.4 to 2.3 0.52 67.78	.1 to .8 0.06 81.13	.3 to 1.5 0.27 68.23	3 to 27 52.27 51.67	0 to 15 27.66 118.74	16 to 34 31.92 20.43
9L 34/ICCC	45 to 53 17.31 8.38	1.5 to 2.8 0.45 29.86	.3 to .7 0.04 40.0	1.2 to 2.1 0.22 27.32	27 to 32 8.35 9.52	7 to 7 0 0	20 to 25 7.18 12.21
Qalandri	40 to 50 12.46 7.88	.4 to 3.1 1.44 75.82	.1 to .8 0.09 75.97	.3 to 2.3 0.81 76.03	8 to 24 27.77 28.58	0 to 15 26.93 76.55	20 to 28 8.18 1.46

for among groups, among sub-groups and within sub-groups have been shown. Variance components for groups and subgroups have also been calculated and presented in Table4. Among groups source of variation represents the differences between parents and hybrids while among subgroups refer to differences between the hybrids of one CMS line as compared to the other. Within subgroups portion of means squares is the error term. Variance components for groups and subgroups, calculated following Sokal & Rohlf (1981), substantiate the additivity of variances between parents and hybrids and among hybrids.

The results of Table 4 indicate highly singificant differences between parents and hybrids for all the characters under study. This is expected because the *hirsutum* pollinators, the CMS lines and the hybrids derived from them came from different origin and hence they are ought to perform significantly different from one another. Two hybrid groups when compared between themselves did not differ in their performance for all the characters except number of motes per boll. The trend performance of individual hybrid was more or less the same. The difference in producing number of motes per boll with respect to individual hybrid was due to the compatibility of individual CMS line to bear successful fertilization with respective pollinator. Different number of motes per boll for different hybrids also reflect the behaviour of pollinators with respect to heteromorphic incompatibility. The variance components for among groups were singificant for days to maturity, weight of seedcotton per boll which imply that there was added variance (in additon to error variance) for these characters due to variability accounting for the differences between parents and hybrids. Subgroups variance components were nonsignificiant and hence no added variance could be interpreted due to differences within the hybrids.

Heterosis estimates:- The estimates of heterosis were considered as the percentage increase of a particular hybrid for a particular character as calculated against the check variety (Qalandri in the present case) as considered and defined by Meredith & Bridge (1972). Accordingly, the heterotic values for seven quantitative characters considered in this study have been given in Table 5. The highest heterosis for days to maturity was calculated for hybrid Des-hams-16 x M-106. All the hybrids showed positive heterosis ranging from 5.85 to 33.88% against the common check variety Qalandri which secured only 37.24 days from the date of boll set to the date of maturity. This implied that the hybrids matured from 5.85 to 33.88% late as compared to the check variety. Thus positive heterosis in case of days to maturity may be regarded as an undesirable attribute as every breeder expects his variety to be early maturing.

In case of yield of seedcotton per boll, all the hybrids showed negative heterosis ranging from 28.06% to -68.38%, the maximum being -28.06% for hybrid Des-hams-16 x IL-34 and minimum (-68.38%) for Tamcot-778 x M-106. It may also be mentioned that negative heterosis obtained in the present studies, for yield of seedcotton is also undesir-

Table 4. Mean squares from the analysis of variance among parents and hybrids obtained from cytoplasmic male-sterile lines of cotton for seven quantitative characters.

Character	Among groups DF = 1	Among Subgroups DF = 1	Within Subgroups DF = 24 (error)	Variance components	
				among groups	among subgroups
Days to maturity	225.75**	1.27	5.53	19.06*	–0.950
Seedcotton per boll	18.54**	0.06	0.16	1.546*	–0.020
Lintocotton per boll	1.19**	0.005	0.14	0.118	–0.031
Weight of seeds per boll	8.74**	0.06	0.10	26.70*	0.750
Number of seeds per boll	340.81**	17.04	13.65	0.726*	–0.008
Number of motes per boll	51.59**	9.02*	1.77	2.94	1.61
Ginning outturn percent	141.65**	3.59	7.16	11.802	–0.793

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

Table 5. Estimates of heterosis for bybrids obtained from cytoplasmic male-sterile lines by crossing them with *hirsutum* pollinators for seven quantitative characters.

Combination		Days to maturity	Seed-cotton per boll (gms)	Lint-cotton per boll (gms)	Wt. of seeds boll (gms)	Seeds per boll	Motes per boll	g.o.t%
CMS, Tamcot-778								
Polli-	CRIS-1/80	13.42	–49.03	–45.55	–50.45	–30.96	– 3.00	– 5.06
nators	ST-3	12.91	–58.70	–66.77	–55.45	–33.80	+161.5	–33.94
	CRIS-13/80	15.09	–52.25	–48.88	–53.63	–27.50	+180.5	– 4.48
	15A-292/4C	18.60	–42.58	–40.00	–44.09	–28.33	+100.0	– 8.46
	W-1107	18.36	–57.74	–61.11	–55.90	–38.60	+ 62.50	–19.78
	47/1-28/1	12.45	–65.48	–72.22	–68.18	–31.02	+ 78.0	–26.77
	M-106	13.66	–68.00	–60.00	–59.54	–50.83	+ 75.0	–12.50
	9L 34 ICCC	27.55	–60.00	–60.00	–59.54	–50.83	+ 75.0	–12.50
	Qalandari	19.87	–59.77	–57.77	–61.36	–39.20	– 4.0	–13.85
CMS, DES-HAMS 16								
Polli-	CRIS-1/80	17.61	–57.41	–57.77	–57.27	–23.33	+190.0	–11.65
nators	ST-3	18.68	–48.38	–62.22	–42.72	–24.66	+ 80.0	–28.97
	CRIS-13/80	14.39	–59.35	–60.00	–58.81	–26.00	+200.0	– 7.86
	15A-292/4C	10.55	–55.48	–53.33	–56.36	–25.90	+227.0	– 9.72
	W-1107	15.46	–40.32	–38.88	–40.90	–30.00	+ 25.0	–22.80
	47/1-28/1	5.82	–64.51	–65.55	–64.09	–20.83	+287.5	–15.21
	M-106	33.83	–65.80	–67.77	–65.45	–53.33	+121.5	–15.21
	9L 34 ICCC	33.37	–28.06	–44.44	–21.36	+ 1.10	+250.0	–31.91
	Qalandari	20.24	–49.03	–56.66	–45.90	–38.53	+239.0	–24.84

able in the breeding programmes as no breeder would like that this variety should be less yielding when the prime object of every breeding programme is for high yield. Hence positive heterosis should be taken as criterion while selecting the hybrids with high heterosis because they are expected to produce high yielding cultivars. Same is the case with lintcotton yield per boll, weight of seeds per boll and number of seeds per boll as these components are directly proportional to yield of seedcotton. Hence negative heterosis for yield and yield components is not desirable and progenies with negative or low hybrid vigour may be discarded during selection procedures. Ginning outturn percentage also holds good as yield of seedcotton because high ginning outturn is desired in every cotton breeding programme. In the present study, negative heterosis values have been obtained for lintcotton yield, weight of seeds per boll, number of seeds per boll and ginning outurn for all the hybrids and therefore these combinations are not suitable for further utilization. Unlike yield and yield components, the hybrids scored high positive heterosis for number of motes per boll but since the presence of larger number of immature seeds per boll is not desired, high heterosis for this character is also undesirable and hybrids with maximum negative heterosis may be selected if only this character is incorporated in the progenies.

Combining ability of pollinator parents:- Combining ability *per se* may be defined as the capability of two parents to combine in such a way that the desireable characters are transmitted to their progeny. The term general combining ability applies to the mean performance of a particular variety in a series of crosses with respect to a particular character and specific combining ability is the deviation of the performance of a particular cross from the mean of general combining abilities of parental lines. The object of estimating general combining ability of pollinator lines in this case was to select the best combiner pollinator and then to produce our own desired cytoplasmic male-sterile line of cotton for the hybrid cotton breeding programme. The estimates of general combining abilities of the pollinator lines are given in Table 6. The results of Table 6 reveal negative values of general combining abilities for all the characters and for all the pollinators. This gives an idea that the *hirsutum* pollinators used onto these cytoplasmic male-sterile lines are not suitable in the present case and therefore our own CMS 'A' lines if developed from these pollinators will not be desirable in further breeding programme. Such early generation testing for combining ability has largely been advocated as it saves time on one hand, and provides adequate information to discard the undesirable material in the initial stages on the other hand, rather than to realize after four or five crossing generations that these lines were not suitable and may be replaced by another ones.

The correlations between the yield of seedcotton per boll (treating it as dependent variable) and rest of the characters (treating them as independent variables) were also calculated from the data in Table 1 and the correlation coefficients are given in Table 7. The purpose of estimating the correlation values was to study the extent by which the yield is being affected with the change in independent variables like days to maturity,

Table 6. Estimates of general combining ability of pollinator parents for seven quantitative characters after crossing them onto CMS lines and Egyptian varieties of cotton

Pollinators	Days to maturity	Seed-cotton	Lint-cotton yield	Wt. of seeds per boll	Number of seeds per boll	Number of Motes per boll	g.o.t%
CRIS-1/80	–13.611	–0.994	–0.262	–0.725	–14.329	–3.492	–18.803
ST-3	–31.581	–0.997	–0.297	–0.695	–14.508	–3.336	–20.994
CRIS-13/80	–31.694	–1.019	–0.269	–0.737	–14.295	–2.939	–18.596
15A-292/4C	–31.711	–0.957	–0.249	–0.702	–14.326	–3.092	–18.873
W-1107	–31.462	–0.957	–0.258	–0.690	–14.842	–3.776	–20.030
47/1-28/1	–32.288	–1.099	–0.307	–0.802	–14.225	–2.982	–20.001
M-106	–30.732	–1.117	–0.299	–0.806	–16.164	–3.483	–19.401
9L 34 ICCC	–30.021	–0.913	–0.264	–0.640	–14.134	–3.098	–20.211
Qalandri	–31.128	–1.001	–0.277	–0.723	–15.334	–3.355	–19.846

Table 7. Correlation coefficients between yield of seedcotton per boll and other quantitative characters

Combination	Pollinator Parents DF = 8	Hybrids from CMS lines DF = 17
Seedcotton yield and days to maturity	0.11	0.24
Seedcotton yield and lintcotton yield	0.82**	0.78**
Seedcotton yield and weight of seeds/voll	0.87**	0.90**
Seedcotton yield and number of seeds/boll	0.72*	0.58*
Seedcotton yield and number of motes/boll	–0.11	0.08
Seedcotton yield and ginning outturn %age	0.35	–0.26

*Significant at 5% level; **Significant at 1% level.

lintcotton yield, weight of seeds per boll, number of seeds per boll, number of motes per boll and ginning outturn percentage. The results of Table 7 reveal that the yield of seedcotton per boll was positively correlated with lintcotton per boll, weight of seeds per boll and the number of seeds per boll. Ginning outturn percentage did not carry singificant association with yield of seedcotton. Same was the position with number of motes per boll.

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