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RESEARCH ARTICLE

EXPLORATION OF POSSIBILITIES OF F_2 COTTON HYBRIDS FOR UTILIZATION AS COMMERCIAL CROP

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Abstract

Exploiting heterosis is one of the methods to increase cotton yields that have stagnant in recent years. Thus, an experiment was conducted during the years 2009-2011 to explore the possibilities of utilization of some F_2 hybrid combinations for commercialization. Ten F_1 and F_2 hybrids and their 6 parents were tested in a four replicated randomized complete block design for their economic traits at Sindh Agriculture University, Tandojam Farm. Results revealed that out of 10, 8 F_1 hybrids gave positive mid parent heterosis in F_1 generation during the year 2010, whereas positive better parent heterosis was observed in 5 hybrids for seed cotton yield. Regarding heterosis in F_2 generations, it was observed that 5 F_2 hybrids gave mid parent heterosis while 4 gave positive heterosis against better parent values. The maximum increase of 13.88% over mid parent was exhibited by the F_1 hybrid combination CRIS-342 x MNH-886 and the same combination gave 20.46% increase over mid parent in F_2 generation. It is interesting to note that this combination has shown increased hybrid vigour (heterosis) in F_2 generation as compared to F_1 generation. Thus the combination CRIS-342 x MNH-886 may be used commercially because of the fact that the F_1 seed production is very expensive hence this combination may serve the purpose of high yields through heterosis breeding and 20% increase is quite satisfactory.

Introduction

Because of difficulty in producing F_1 hybrid seed by hand emasculation and pollination, wide use of heterosis in cotton production has been limited in Pakistan. Thus use of F_2 hybrids with considerable yield gains has become imperative. The use of heterosis has long been one of the objectives of cotton breeders. The yield increase of hybrids over mid parent, better parent or best commercial cultivar has been documented in numerous reviews. Breeding research needs to address all possibilities to increase yield including the use of heterosis (Meredith & Brown, 1998). The major limiting factor in using heterosis in cotton is the lack of an efficient crossing system and difficulty of producing F_1's seed on commercial scale by hand emasculation and pollination (Wu *et al*. 2004). To avoid this constrain, commercial use of F_2 hybrids has been proposed (Olvey, 1986). The yield performance some F_2 cotton hybrids (Meyer, 1975; Sheetz & Quisenberry, 1986) showed that there existed a potential for the success use of F_2 hybrids. Meredith & Bridge, 1972) reported that one of six F_2 hybrids yielded 10% more lint than the best yielding parent and equaled F_1 hybrid. Olvey, (1986) after a three years study concluded that some F_2 hybrids showed significant increase in seedling vigour, fiber properties with yields 10 to 24% greater than the best yielding parent. The F_2 hybrids offer heterogeneous population which might result in a greater range of adaptation of F_2's as compared to their parents or F_1 hybrids. Iqbal *et al*. (2003) revealed that F_2 generation can also be cultivated in field for use of heterotic vigor and cost of seed production can be decreased. F_2 hybrids with lower inbreeding depression in yield and superior performance than well adapted cultivars have been found (Meredith, 1990). The existence of such populations lends credibility to use F_2's as hybrid cotton. Tang, *et al*. (1993) reported acceptable level of F_2 heterosis for yield. Fiber traits of F_2 were similar to mid parental values. Baure and Green (1996) also reported F_2's greater superiority over their best parents. Considering in view the results by previous researchers, the present study was initiated to explore the possibilities of commercializing seed F_2 hybrid combinations which can excel their parents and even F_1 hybrids.

Material and Methods

The heterotic studies and inbreeding depression of yield and yield components of F_2 population in upland cotton were conducted at Sindh Agriculture University, Tandojam Farm during 2009-10 and 2010-11 crop seasons. The experimental material consisted of eight upland cotton genotypes viz: CRIS-342, MNH-886, CRIS-121, CRIS-129, Tarzan-1, BT-121, TARZAN-2 and SUN-1 and their 15 F_1 and F_2 combinations.
The parental material and F_1 were sown on 10^{th} of May 2009 and 7^{th} of May 2010 respectively in a Randomized Complete Block (RCB) design replicated four times. During 2011, parental material was sown along with F_2 hybrids in the same fashion as sown in 2010. Each treatment had three rows of 5 meters length, 30 and 75 centimeters plants and row spacing respectively. Recommended cultural practices were carried out and all the entries were grown under uniform conditions to minimize environmental variations. Picking was made on single plant basis and data were recorded on three parameters viz; number of sympodial branches per plant, number of bolls per plant and seedcotton yield per plant. Data of F_1, F_2 and parental lines were analyzed according to Steel and Torrie (1980) and were subjected to Duncan's Multiple Range Test. Heterosis was calculated in terms of percent increase or decrease of F_1 over mid parent and better parent values and of F_2 over F_1 values (Fehr, 1987).

Result and Discussion

Heterosis and inbreeding depression studies were conducted to see whether some F_2 combinations are worth to be utilized commercially, for this purpose, an experiment was conducted at Sindh Agriculture University, Tandojam. Results revealed that genotypes utilized in the experiment were statistically significant in their mean performance. TARZAN-2 was the top performer during 2009 for all the three traits studied. It formed 27.38 average sympodial branches per plant, 39.56 average number of bolls per plant and produced 156.12g average seed cotton yield per plant (Table-1).

F_1 heterosis estimates for number of sympodial branches per plant

15 F1 hybrids were studied for sympodial branches per plant during 2010 cotton season. Heterosis and heterobeltiosis estimates are given in Table-2 which revealed that out of 15 hybrids, 14 and 6 gave positive heterosis and heterobeltiosis respectively. The range of heterosis was -0.34% to 25.69%, whereas the heterobeltiosis range was recorded from -7.21% to 9.34%. Maximum heterosis of 25.69% on mid parent value was given by F_1 hybrid combination SUN-1 x MNH-886 followed by TARZAN-2 x Tarzan-1 which recorded the increase of 15.29%, whereas, better parent heterosis of 9.34% was given by the combination MNH-886 x Tarzan-1 followed by CRIS-121 x MNH-886 (8.47%).

F_1 heterosis estimates for number of bolls per plant

The data regarding number of bolls per plant of 15 F1 hybrid combinations sown during 2010 cotton season are presented in Table-3. Out of 15 hybrids, 13 and 10 gave positive heterosis (mid parent) and heterobeltiosis (better parent) respectively. The range of heterosis was -15.98% to 29.48%, whereas the heterobletiosis range was recorded from -16.03% to 14.33%. Maximum heterosis of 29.48% on mid parent value was given by the combination MNH-886 x TARZAN-2 followed by SUN-1 x MNH-886 which recorded the increase of 25.49%, whereas, maximum better parent heterosis of 14.33 was given by the combination TARZAN-2 x SUN-1 followed by TARZAN-2 x Tarzan-1 (12.92%).

F_1 heterosis estimates for seed cotton yield per plant

The data regarding seed cotton yield per plant of 15 F1 hybrid combinations sown during 2010 cotton season are presented in Table-4. Out of 15 hybrids, 13 and 9 gave positive heterosis on mid parent and better parent value respectively. The range of percent increase or decrease over mid parent was recorded from -7.96% to 34.88%, whereas over better parent value, it was from -24.32% to 8.07%. Maximum heterosis of 34.88% on mid parent value was given by the combination CRIS-121 x TARZAN-2 followed by TARZAN-2 x Tarzan-1 which recorded the increase of 25.45%, whereas, maximum better parent heterosis of 8.07% was given by the combination TARZAN-2 x SUN-1 followed by CRIS-121 x MNH-886 (7.31%).

The data regarding mean performance of eight genotypes during the year 2011 which were planted besides 15 F_2 hybrid combinations are presented in Table-5 which revealed that TARZAN-2 was the top performer during 2011 season similar to 2010 year for all the three traits studied. It formed 28.66 average number of sympodial branches per plant, 45.58 average number of bolls per plant and produced 123.76g average seed cotton yield per plant.

F_2 heterosis estimates for number of sympodial branches per plant

15 F_2 hybrids were studied for sympodial branches per plant during 2011 cotton season. Results regarding increase or decrease of F_2 over F_1 are given in Table-6 which revealed that out of 15 F_2 hybrids, 4 gave positive and 11 gave negative heterosis over their corresponding F_1 hybrids. The range of heterosis was from -12.79% to 12.76%. Maximum heterosis of 12.76% was given by F_2 hybrid combination CRIS-129 x Tarzen-1 followed by CRIS-342 x MNH-886 which recorded the increase of 8.03%.

F_2 heterosis estimates for number of bolls per plant

15 F_2 hybrids were studied for number of bolls per plant during 2011 cotton season. Results regarding increase or decrease of F_2 over F_1 are given in Table-7 which revealed that out of 15 F_2 hybrids, 4 gave positive and 11 gave negative heterosis over corresponding F_1 hybrids. The range of heterosis recorded was from -11.53% to 15.90%. Maximum heterosis of 15.90% was given by F_2 hybrid combination CRIS-342 x MNH-886 followed by TARZAN-2 x SUN-1 which recorded the increase of 12.29%.

F_2 heterosis estimates for seed cotton yield per plant

During the cotton season 2011, 15 F_2 hybrids were studied for seed cotton yield per plant. Percent increase or decrease of F_2 over F_1 is given in Table-8 which revealed that out of 15 F_2 hybrids, only 2 hybrids gave positive and 13 gave negative heterosis over corresponding F_1 hybrids. The range of increase or decrease was -13.61% to 16.12%. Maximum heterosis of 16.12% was given by F_2 hybrid combination CRIS-342 x MNH-886 followed by CRIS-129 x Tarzan-1 which recorded the increase of 7.10%.

The theme of this research project was to explore the possibilities of F_2 hybrids to be commercially utilized due to the fact that production of F_1 hybrid seed is very expensive and laborious. Only little quantity of F_1 hybrid seed is produced which can not be utilized commercially. Many researchers like Baure and Green (1996); Iqbal *et al*. (2003); Meredith (1990); Olvey (1986); Tang *et al*. 91993) and Wu *et al*. 92004) have suggested commercialization of F_2 generation hybrids. They all are of the opinion that isolation of some specific combinations in F_2 generation which can excel even F_1 hybrids may prove beneficial for cotton growers to achieve their production targets. During present studies, it has been observed that out of 15 hybrid combinations, 2 combinations (CRIS-342 x MNH-886 and CRIS-129 x Tarzan-1) from F_2 generation can pave the way towards higher seed cotton yield. These two combinations have excelled their F_1 hybrids in producing higher number of sympodial branches per plant, higher number of bolls per plant and higher seed cotton yield per plant. To minimize the expenses and laborious work on producing F_1 hybrids on commercial scale, these two combinations are the right answer to produce higher yields in F_2 generation and to save the money, labour and time.

Table-1: Average performance of eight genotypes for yield and yield contributing traits during 2010 at Sindh Agriculture University, Tandojam Farm

Genotypes	Number of sympodial branches plant^{-1}	Number of bolls plant^{-1}	Seed cotton yield plant^{-1} (gm)
1-CRIS-342	22.18b	35.12b	135.42b
2-MNH-886	17.18bc	27.33c	112.15cd
3-CRIS-121	20.53bc	32.65bc	116.24cd
4-CRIS-129	22.41b	35.62b	123.96bc
5-Tarzan-1	16.18c	25.58c	91.34d

6-BT-121	16.73c	26.57c	88.51d
7-TARZAN-2	27.38a	39.56a	156.12a
8-SUN-1	23.79b	32.68bc	127.31bc

Means followed by similar letter do not differ from each other at 5% probability level according to DMR Test

Table-2: Heterosis estimates in some upland cotton F_1 hybrids for number of sympodial branches per plant during 2010 at Sindh Agriculture University, Tandojam Farm

Hybrids	Female Parent	Male Parent	F_1 Hybrid	Mid Parent	Better Parent	% increase or decrease of F_1 over	
						Mid Parent	Better Parent
1. CRIS-342 x MNH-886	22.18	17.18	23.13	19.68	22.18	14.92	4.11
2. CRIS-121 x MNH-886	20.53	17.18	22.43	18.86	20.53	15.94	8.47
3. CRIS-129 x MNH-886	22.41	17.18	24.45	19.80	22.41	19.04	8.34
4. SUN-1 x MNH-886	23.79	17.18	25.73	20.49	23.79	25.69	8.15
5. MNH-886 x Tarzan-1	17.18	16.18	18.95	16.68	17.18	11.98	9.34
6. MNH-886 x BT-121	17.18	16.73	16.99	16.96	17.18	0.21	-1.12
7.MNH-886 x TARZAN-2	17.18	27.38	25.88	22.28	27.38	16.16	-5.48
8. BT-121 x Tarzan-1	16.73	16.18	16.4	16.46	16.73	-0.34	-2.01
9.CRIS-121 x TARZAN-2	20.53	27.38	27.21	23.96	27.38	13.56	-0.62
10. CRIS-121 x BT-121	20.53	16.73	19.38	18.63	20.53	3.87	-5.93
11. CRIS-129 x BT-121	22.41	16.73	22.2	19.57	22.41	11.85	-0.95
12. CRIS-121 x Tarzan-1	20.53	16.18	19.15	18.36	20.53	4.15	-7.21
13. CRIS-129 x Tarzan-1	22.41	16.18	20.51	19.30	22.41	5.92	-9.26
14. TARZAN-2 x SUN-1	27.38	23.79	28.34	25 .09	27.38	12.95	3.51
15. TARZAN-2 x Tarzan-1	27.38	16.18	25.11	21.78	27.38	15.29	-8.29

Table-3: Heterosis estimates in some upland cotton F_1 hybrids for number of bolls per plant during 2010 at Sindh Agriculture University, Tandojam Farm

Hybrids	Female Parent	Male Parent	F_1 Hybrid	Mid Parent	Better Parent	% increase or decrease of F_1 over	
						Mid Parent	Better Parent
1. CRIS-342 x MNH-886	35.12	27.33	37.43	31.23	35.12	16.58	6.17
2. CRIS-121 x MNH-886	32.65	27.33	34.54	29.99	32.65	13.17	5.47
3. CRIS-129 x MNH-886	35.62	27.33	37.68	31.48	35.62	16.47	5.47
4. SUN-1 x MNH-886	38.18	27.33	41.11	32.76	38.18	25.49	7.67
5. MNH-886 x Tarzan-1	27.33	35.58	36.66	31.46	35.58	16.53	3.04
6. MNH-886 x BT-121	27.33	26.57	27.19	26.95	27.33	0.88	-0.51
7.MNH-886 x TARZAN-2	27.33	39.56	43.31	33.45	39.56	29.48	3.75
8. BT-121 x Tarzan-1	26.57	35.58	34.99	31.08	35.58	12.58	-1.69
9.CRIS-121 x TARZAN-2	32.65	39.56	42.13	36.11	39.56	16.67	6.50
10. CRIS-121 x BT-121	32.65	26.57	33.01	29.61	32.65	10.30	1.09
11. CRIS-129 x BT-121	35.62	26.57	35.15	31.10	35.62	11.54	-1.34
12. CRIS-121 x Tarzan-1	32.65	35.58	33.93	34.12	35.58	- 0.56	-4.64
13. CRIS-129 x Tarzan-1	35.62	35.58	29.91	35.60	35.62	-15.98	-16.03
14. TARZAN-2 x SUN-1	39.56	38.18	45.23	38.87	39.56	16.36	14.33

15. TARZAN-2 x Tarzan-1	39.56	35.58	44.67	37.57	39.56	18.90	12.92

Table-4: Heterosis estimates in some upland cotton F_1 hybrids for seed cotton yield per plant during 2010 at Sindh Agriculture University, Tandojam Farm

Hybrids	Female Parent	Male Parent	F_1 Hybrid	Mid Parent	Better Parent	% increase or decrease of F_1 over	
						Mid Parent	Better Parent
1. CRIS-342 x MNH-886	135.42	112.15	143.54	123.79	135.42	13.76	5.66
2. CRIS-121 x MNH-886	116.24	112.15	125.41	114.20	116.24	8.94	7.31
3. CRIS-129 x MNH-886	123.96	112.15	131.72	118.06	123.96	10.37	5.89
4. SUN-1 x MNH-886	127.31	112.15	134.49	119.73	127.31	12.37	5.64
5. MNH-886 x Tarzan-1	112.15	91.34	113.24	101.75	112.15	10.15	0.96
6. MNH-886 x BT-121	112.15	88.51	101.23	100.33	112.15	0.89	-10.79
7. MNH-886 x TARZAN-2	112.15	156.12	162.53	134.14	156.12	21.16	4.11
8. BT-121 x Tarzan-1	88.51	91.34	92.51	89.93	91.34	2.79	1.26
9. CRIS-121 x TARZAN-2	88.51	156.12	164.98	122.32	156.12	34.88	5.56
10. CRIS-121 x BT-121	116.24	88.51	103.75	102.38	116.24	1.33	-12.04
11. CRIS-129 x BT-121	123.96	88.51	114.24	106.24	123.96	7.01	-8.51
12. CRIS-121 x Tarzan-1	116.24	91.34	99.46	103.79	116.24	-4.35	-16.87
13. CRIS-129 x Tarzan-1	123.96	91.34	99.71	107.65	123.96	-7.96	-24.32
14. TARZAN-2 x SUN-1	156.12	127.31	168.78	141.72	156.12	19.10	8.07
15. TARZAN-2 x Tarzan-1	156.12	91.34	155.22	123.73	156.12	25.45	-0.58

Table-5: Average performance of eight genotypes for yield and yield contributing traits during 2011 at Sindh Agriculture University, Tandojam Farm

Genotypes	Number of sympodial branches $plant^{-1}$	Number of bolls $plant^{-1}$	Seed cotton yield $plant^{-1}$ (gm)
1-CRIS-342	21.25bc	43.32a	104.35b
2-MNH-886	18.59c	38.97b	72.41d
3-CRIS-121	27.44a	41.71ab	98.15bc
4-CRIS-129	26.38ab	36.43bc	96.71bc
5-Tarzan-1	19.53c	39.55b	77.35d
6-BT-121	24.51ab	35.75c	87.43cd
7-TARZAN-2	28.66a	45.58a	123.76a
8-SUN-1	24.59ab	37.33bc	117.54ab

Means followed by similar letter do not differ from each other at 5% probability level according to DMR Test

Table-6: Heterosis estimates in some upland cotton F_2 hybrids for number of sympodial branches per plant during 2011 at Sindh Agriculture University, Tandojam Farm

	F_1 Hybrid	F_2 Hybrid	% increase or decrease of

Hybrids			F_2 over F_1
1. CRIS-342 x MNH-886	23.13	25.15	8.03
2. CRIS-121 x MNH-886	22.43	21.23	-5.65
3. CRIS-129 x MNH-886	24.45	23.37	-4.62
4. SUN-1 x MNH-886	25.73	26.52	2.97
5. MNH-886 x Tarzan-1	18.95	17.13	-10.62
6. MNH-886 x BT-121	16.99	15.24	-11.48
7. MNH-886 x TARZAN-2	25.88	24.53	-5.50
8. BT-121 x Tarzan-1	16.41	14.54	-12.79
9.CRIS-121 x TARZAN-2	27.21	26.48	-2.75
10. CRIS-121 x BT-121	19.38	18.94	-2.32
11. CRIS-129 x BT-121	22.2	21.55	-3.01
12. CRIS-121 x Tarzan-1	19.15	18.54	-3.29
13. CRIS-129 x Tarzan-1	20.51	23.51	12.76
14. TARZAN-2 x SUN-1	28.34	28.89	1.90
15. TARZAN-2 x Tarzan-1	25.11	23.56	-6.57

Table-7: Heterosis estimates in some upland cotton F_2 hybrids for number of bolls per plant during 2011 at Sindh Agriculture University, Tandojam Farm

Hybrids	F_1 Hybrid	F_2 Hybrid	% increase or decrease of F_2 over F_1
1. CRIS-342 x MNH-886	37.43	44.51	15.90
2. CRIS-121 x MNH-886	34.54	33.52	-3.04
3. CRIS-129 x MNH-886	37.68	35.31	-6.71
4. SUN-1 x MNH-886	41.11	40.77	-0.83
5. MNH-886 x Tarzan-1	36.66	35.57	-3.06
6. MNH-886 x BT-121	27.19	27.41	0.80
7. MNH-886 x TARZAN-2	43.31	41.87	-3.43
8. BT-121 x Tarzan-1	34.99	33.54	-4.32
9.CRIS-121 x TARZAN-2	42.13	41.96	-0.40
10. CRIS-121 x BT-121	33.01	31.51	-4.76
11. CRIS-129 x BT-121	35.15	37.41	6.04
12. CRIS-121 x Tarzan-1	33.93	30.42	-11.53
13. CRIS-129 x Tarzan-1	29.91	28.91	-3.45
14. TARZAN-2 x SUN-1	45.23	51.57	12.29
15. TARZAN-2 x Tarzan-1	44.67	40.19	-11.14

Table-8: Heterosis estimates in some upland cotton F_2 hybrids for seed cotton yield per plant during 2011 at Sindh Agriculture University, Tandojam Farm

Hybrids	F_1 Hybrid	F_2 Hybrid	% increase or decrease of F_2 over

			F_1
1. CRIS-342 x MNH-886	143.54	171.12	16.12
2. CRIS-121 x MNH-886	125.41	123.34	-1.68
3. CRIS-129 x MNH-886	131.72	125.64	-4.84
4. SUN-1 x MNH-886	134.49	124.53	-8.00
5. MNH-886 x Tarzan-1	113.24	108.61	-4.26
6. MNH-886 x BT-121	101.23	94.21	-7.45
7. MNH-886 x TARZAN-2	162.53	153.25	-6.06
8. BT-121 x Tarzan-1	92.51	85.35	-8.39
9.CRIS-121 x TARZAN-2	164.98	156.77	-5.24
10. CRIS-121 x BT-121	103.75	91.32	-13.61
11. CRIS-129 x BT-121	114.24	103.35	-10.54
12. CRIS-121 x Tarzan-1	99.46	91.69	-8.47
13. CRIS-129 x Tarzan-1	99.71	107.33	7.10
14. TARZAN-2 x SUN-1	168.78	158.25	-6.65
15. TARZAN-2 x Tarzan-1	155.22	145.72	-6.52

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