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Reciprocal selection in segregating generations to identify potential combiners of cotton (*Gossypium hirsutum* L.)

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SUMMARY

Two F_1 hybrids (RAHH-102 and RAHH-136), which are distinct, were identified through their predicted double cross performance as potential sources of inbred lines for hybrid cotton cultivars. F_4 lines were derived from these crosses and utilized in a study on variability for combining ability. Sets of 26 lines each from the two crosses were crossed in a reciprocal fashion to the F_1 parent as a tester for combining ability. The improvements in performance of F_1 hybrids derived by crossing the best performing F_4 lines as predicted by their reciprocal test cross performance indicated that progress could be made for gain in combining ability through a breeding procedure similar to reciprocal recurrent selection in cross pollinated crops.

Key words : Combining ability, Segregating generation, Reciprocal selection

Cotton improvement programmes that concentrate on the development of hybrids have contributed to improving cotton productivity (Dagaonkar and Malkandale, 1993). However, genetic gain in yield potential of hybrids appears to be approaching stagnation. In breeding programmes aimed at improving productivity of pure lines, *i.e.*, not hybrids, variability is created and exploited by practicing selecting for yield during segregating generations. However, improving the performance of hybrids requires that scientists consider the combining ability of potential parental material (Patil and Patil, 2003). In cross pollinated crops like maize, hybrid breeding programmes are supplemented by regular systematic programmes aimed at improving combining ability (Patil and Pandit, 1991). Systematic attempts have not been practiced in cotton to create variability for combining ability, *i.e.*, combining ability was not considered as a trait for improvement in hybrid breeding programmes. Reciprocal recurrent selection schemes for improving combining ability have been an integral part of hybrid breeding programmes in cross pollinated crops and such programmes have contributed to success of hybrid maize. The procedures of improving combining ability in cross pollinated species can not be followed in cotton without suitable modification. Hence, there is a need for defining procedures of improving combining ability to serve as a pre-requisite in hybrid breeding in cotton. It is possible to recombine two, four or more lines (selected for combining ability) by single, double or multiple crossing or simulated intermating. Generally, individual plants in the F_4 generation are selfed and crossed with a tester line to initiate the selection of improved inbreds. The objective of this research was to determine the combining ability among segregant F_4 lines within two diverse populations.

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MATERIALS AND METHODS

Following analysis (data not shown) of a large set of single crosses, two single cross hybrids RAHH 102 (RAH10 ´ RA100) and RAHH 136 (RAH20 ´ RAH200) were selected for this study based on their predicted double cross performance(Patil and Patil, 2003). Plants within each population were advanced to the F_4 generation. Twenty-six, *i.e.* single plants, from each cross were selected randomly and crossed to the reciprocal F_1 hybrid as the tester parent. Thus, F_4 plants from RAHH 102 were crossed with RAHH 136 F_1 and random F_4 plants from RAHH 136 were crossed to RAHH 102 F_1 to established two sets of reciprocal hybrids. A field evaluation was conducted for two set of hybrids in Randomized Complete Block Design with three replications having two rows of 5 metre length. The whole experiment *i.e.* crossing and evaluation of the hybrids was conducted at University of Agricultural Sciences Dharwad during 2005-06 which receives an annual rainfall of 750 mm. Proper pest and disease control measure was taken to avoid economic loss. The characterization of the combining ability status of two sets of F_4 (26 each) lines was determined based on the performance of the crosses (seed cotton yield) compared with the F_1 reciprocal testers. Each F4 line was assigned to one of four classes based on the overall mean of all crosses. These classes were 1 (greater than (single cross parental mean + 1 sd unit)) , 2 (equal to the (single cross parental mean + 1 sd unit) , 3 (equal to the single cross mean – 1 sd unit) , and 4 (less than (single cross parental mean – 1 sd unit)) as suggested by Patil (1995). Thus, for lines of RAHH 102, four classes of combining ability status were defined as E_1, E_2, E_3, and E_4, respectively. Similarly, F_1, F_2, F_3, and F4 classes were defined representing the decreasing order to superiority of the crosses for the lines of RAHH 136.

Per cent improvement in performance of reciprocal test cross hybrids over the mean of the reciprocal hybrid parents was calculated as an estimate of the combining ability of the each population. Hybrids were then developed by crossing the best combining inbred lines in all possible combinations in the following season. Performance of these hybrids, F_5 x F_5, were determined with three replication in RBD having three rows of 5 metre length during 2006 in the same location . Hybrids were compared with a commercial cultivar, Bunny, and the original two single cross.

RESULTS AND DISCUSSION

Four lines of RAHH 102 lines with F_1 RAHH 136 hybrids exceeded the mean of all the 26 test cross hybrids by more than one standard deviation unit (Table 1). These were developed from lines R-18 (102), R-25 (102), R-22 (102), and R-26 (102) and yielded 2930, 2804, 2591, and 2582 kg ha^{-1}, respectively compared with the mean of all 26 hybrids of 2173 kg ha^{-1}. Twelve additional lines of RAHH 102 with reciprocal hybrid yielded within one standard deviation above the overall mean while eight

Table 1: Performance of reciprocal crosses derived from the lines RAHH-102 crossed with tester RAHH-136 F_1 during 2004

F_4 line No.	Crosses	Seed cotton yield (kg ha^{-1})	% Improvement over mean of straight crosses	Ranking
R-18 (102)	R-18 (102) x RAHH 136 F_1	2929.89	49.01	E1
R-25 (102)	R-25 (102) x RAHH 136 F_1	2803.73	42.59	E1
R-22 (102)	R-22 (102) x RAHH 136 F_1	2590.61	31.75	E1
R-26 (102)	R-26 (102) x RAHH 136 F_1	2582.01	31.32	E1
R-5 (102)	R-5 (102) x RAHH 136 F_1	2488.1	26.54	E2
R-8 (102)	R-8 (102) x RAHH 136 F_1	2420.63	23.11	E2
R-11 (102)	R-11 (102) x RAHH 136 F_1	2366.4	20.35	E2
R-21 (102)	R-21 (102) x RAHH 136 F_1	2355.82	19.81	E2
R-17 (102)	R-17 (102) x RAHH 136 F_1	2351.85	19.61	E2
R-7 (102)	R-7 (102) x RAHH 136 F_1	2316.14	17.79	E2
R-20 (102)	R-20 (102) x RAHH 136 F_1	2314.81	17.73	E2
R-14 (102)	R-14 (102) x RAHH 136 F_1	2220.9	12.95	E2
R-15 (102)	R-15 (102) x RAHH 136 F_1	2210.98	12.45	E2
R-4 (102)	R-4 (102) x RAHH 136 F_1	2191.14	11.44	E2
R-13 (102)	R-13 (102) x RAHH 136 F_1	2167.99	10.26	E2
R-9 (102)	R-9 (102) x RAHH 136 F_1	2135.58	8.61	E2
R-1 (102)	R-1 (102) x RAHH 136 F_1	2115.74	7.6	E3
R-16 (102)	R-16 (102) x RAHH 136 F_1	2030.42	3.26	E3
R-10 (102)	R-10 (102) x RAHH 136 F_1	2021.83	2.83	E3
R-12 (102)	R-12 (102) x RAHH 136 F_1	2005.29	1.98	E3
R-23 (102)	R-23 (102) x RAHH 136 F_1	1917.99	-2.46	E3
R-19 (102)	R-19 (102) x RAHH 136 F_1	1903.44	-3.2	E3
R-3 (102)	R-3 (102) x RAHH 136 F_1	1883.6	-4.2	E3
R-6 (102)	R-6 (102) x RAHH 136 F_1	1832.01	-6.83	E3
R-24 (102)	R-24 (102) x RAHH 136 F_1	1256.61	-36.09	E4
R-2 (102)	R-2 (102) x RAHH 136 F_1	1086.64	-44.74	E4
	Mean	2173.083		
	Standard deviation (sd)	402.6988		
	Single cross parents			
	RAHH102	2140.21		
	RAHH 136	1792.33		
	Mean of single crosses	1966.27		

hybrids performed within one standard deviation below the mean, and only two R- (102) hybrids yielded more than one standard deviation below the overall mean. The highest yielding hybrid, R-18 (102) x RAHH 136 F_1, produced 49% more seedcotton than the average of two straight crosses, while R-2 (102) x RAHH 136 F_1 yielded 45 % less seedcotton. Four lines of RAHH 136 with RAHH 102 F_1 as a tester produced hybrids which exceeded the mean of two straight crosses by more than one standard deviation unit (Table 2). These were R-2 (136), R-14 (136), R-16 (136), and R-15 (136), which yielded 2817, 2397, 2392, and 2389 kg ha^{-1}, respectively, compared with the mean of two straight crosses of 1930 kg ha^{-1}. Seventeen of these 26 hybrids were in the F_2 or F_3 categories, *i.e.*, within one sd unit of the overall mean, while five hybrids yielded more than one sd below the overall mean. The superior F_4 lines from RAHH 102(four) and from RAHH 136(four) that produced the superior reciprocal hybrids were subsequently crossed to produce all possible F_1 hybrids (Table 3). All hybrids except R-26 (102) x R-15 (136) exceeded (p=0.05) the yield of Bunny, which was not different than the mean yield of RAHH 102 and RAHH 136 in this trial. The numerically highest yielding hybrid was R-25 (102) x R-2 (136) at 3593 kg ha^{-1}, which was 51% higher than Bunny. In conclusion, in the reciprocal recurrent selection scheme proposed herein for cotton, the elite high combiner plants obtained from the reciprocal populations represent gain obtained from practicing selection for combining ability. We propose that such elite lines of the corresponding population can be

Table 2: Performance of reciprocal crosses derived from the lines of RAHH-136 crossed with tester RAHH-102 (F_1) during 2004

F_4 line No..	Crosses	Seed cotton yield (kg ha^{-1})	% Improvement	Ranking
R-2(136)	R-2(136) x RAHH 102 F_1	2817.46	45.96	F1
R-14(136)	R-14(136) x RAHH 102 F_1	2396.83	24.17	F1
R-16(136)	R-16(136) x RAHH 102 F_1	2391.53	23.9	F1
R-15(136)	R-15(136) x RAHH 102 F_1	2388.89	23.76	F1
R-21(136)	R-21(136) x RAHH 102 F_1	2294.31	18.86	F2
R-20(136)	R-20(136) x RAHH 102 F_1	2246.03	16.36	F2
R-12(136)	R-12(136) x RAHH 102 F_1	2240.08	16.05	F2
R-11(136)	R-11(136) x RAHH 102 F_1	2236.77	15.88	F2
R-5(136)	R-5(136) x RAHH 102 F_1	2206.35	14.3	F2
R-19(136)	R-19(136) x RAHH 102 F_1	2200.53	14	F2
R-23(136)	R-23(136) x RAHH 102 F_1	2170.63	12.45	F2
R-6(136)	R-6(136) x RAHH 102 F_1	2132.94	10.5	F2
R-1(136)	R-1(136) x RAHH 102 F_1	2095.24	8.55	F2
R-8(136)	R-8(136) x RAHH 102 F_1	2076.72	7.59	F2
R-3(136)	R-3(136) x RAHH 102 F_1	2035.05	5.43	F2
R-17(136)	R-17(136) x RAHH 102 F_1	1964.29	1.76	F3
R-18(136)	R-18(136) x RAHH 102 F_1	1941.8	0.6	F3
R-7(136)	R-7(136) x RAHH 102 F_1	1906.75	-1.22	F3
R-10(136)	R-10(136) x RAHH 102 F_1	1851.85	-4.06	F3
R-9(136)	R-9(136) x RAHH 102 F_1	1780.42	-7.76	F3
R-26(136)	R-26(136) x RAHH 102 F_1	1710.32	-11.39	F3
R-13(136)	R-13(136) x RAHH 102 F_1	1583.33	-17.97	F4
R-24(136)	R-24(136) x RAHH 102 F_1	1539.68	-20.23	F4
R-4(136)	R-4(136) x RAHH 102 F_1	1536.38	-20.41	F4
R-22(136)	R-22(136) x RAHH 102 F_1	1414.02	-26.74	F4
R-25(136)	R-25(136) x RAHH 102 F_1	1148.38	-40.51	F4
Mean		2011.792		
Standard deviation (sd)		367.1382		
Single cross parents				
	RAHH 136	2110.21		
	RAHH 102	1750.33		
		1930.27		
Mean of single cross parents				

Table 3 : Performance of elite crosses involving best combiners extracted from opposite population

Sr. No.	Pedigrees of F_1 hybrids from superior F_4 lines	Seed cotton yield (kg ha^{-1})	% Improvement over single cross parents	% Improvement over commercial check
1.	R-25 (102) x R-2(136)	3592.7	56.2	51.0
2.	R-18 (102) x R-2(136)	3412.9	48.4	43.5
3.	R-22 (102) x R-2(136)	3225.7	40.2	35.6
4.	R-25 (102) x R-14(136)	3183.4	38.4	33.8
5.	R-25 (102) x R-16(136)	3076.4	33.8	29.3
6.	R-26 (102) x R-14(136)	3051.5	32.7	28.3
7.	R-18 (102) x R-14(136)	3047.3	32.5	28.1
8.	R-26 (102) x R-2(136)	3027.3	31.6	27.3
9.	R-22 (102) x R-14(136)	2994.7	30.2	25.9
10.	R-25 (102) x R-15(136)	2945.8	28.1	23.8
11.	R-26 (102) x R-16(136)	2944.7	28.0	23.8
12.	R-22 (102) x R-16(136)	2896.4	25.9	21.8
13.	R-18 (102) x R-16(136)	2865.2	24.6	20.4
14.	R-22 (102) x R-15(136)	2856.6	24.2	20.1
15.	R-18 (102) x R-15(136)	2756.9	19.9	15.9
16.	R-26 (102) x R-15(136)	2692.7	17.1	13.2
Mean		3035.6	32.0	27.6
Bunny		2378.9		
Mean of single cross parents		2300.0		
	C.D. (P=0.05)	267.1		

intermated to start the next cycle of recurrent selection. In this study, the elite lines *per se* produced highly productive hybrids, indicating the magnitude of improving combining ability achieved through selection practiced in one cycle of reciprocal selection.

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