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Genetic analysis of morpho-physiological parameters in cotton (*Gossypium hirsutum*)

Suman Bala Singh and D. Singh*

Division of Crop Improvement, Central Institute For Cotton Research, Nagpur 440 010

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Abstract

Crosses from 9-parents half dialled of *G. hirsutum* were evaluated in field and mud pots. Both additive and non additive gene action were important in the expression of biomass recovery, water use efficiency, total leaf area, transpiration and yield per plant. The g.c.a. and s.c.a. variances under varied condition indicated the influence of growing conditions on various characters. Laxmi, Reba Pvt 9, Reba B50 and 1301DD were good general combiner for yield, biomass/plant, relative water content and total leaf area. Crosses SRT 1 × B1007, SRT 1 × Reba Pvt 9, B 1007 × 1301DD, Laxmi × Reba B50, Reba B 50 × 170 CO_2 and 1301 DD × 170CO_2 were identified as the best cross combinations for high yield with less biomass production.

Key words : Cotton, drought tolerance, morphophysiological parameters, combining ability.

Introduction

Majority of the area under rainfed cotton in India face multifacet problems caused by intermittent drought or early termination of rainfall which results in big loss to farming community. Although physiological traits involved in drought tolerance have been identified [1, 2] but the inclusion of drought resistance through genetic manipulations have been sporadically attempted in rainfed cotton [3]. The study reported, was therefore undertaken to determine the genetics of some important parameters involved in drought tolerance in rainfed cotton of Central India which can help in future breeding programme.

Materials and methods

The experimental material comprised of F_1 generation of a 9 × 9 half diallel cross raised at the Panjari farm of the Central Institute for Cotton Research, Nagpur. The crop was raised in field in randomise complete block design and in mud pots containing black cotton soil and FYM (3:1) in a randomised design with two replications. One plant per pot was maintained. The plants were subjected to drought at the time of the flowering and boll development stages by withholding irrigation till temporary wilting. Data were recorded on biomass recovery, water use efficiency (WUE), yield stability, total leaf area (T.L.A.), diffusive resistance (DR), leaf temperature, relative water content (RWC), biomass per plant, yield per plant and transpiration coefficient.

Leaf area was measured on leaf area meter (Model LI-3100). The leaf temperature, transpiration and diffusive resistance were recorded on the top fourth leaf using steady state porometer (Model LI-1600). The fourth leaf was sampled and measured for RWC [4]. The data on combining ability were analysed following Griffing [5] method 2 model II.

Results and discussion

Statistical analysis revealed highly significant differences among the F_1's for biomass recovery, water use efficiency, leaf temperature, transpiration and yield per plant under simulated drought conditions. General and specific combining ability variances were found to be significant for biomass recovery, water use efficiency, total leaf area, transpiration and yield per plant suggesting that both additive and non-additive genes are important in the expression of these traits. However, under drought condition, only leaf temperature showed significant g.c.a. and s.c.a. variances while under control conditions total leaf area, diffusive resistance and leaf temperature showed significant g.c.a. and s.c.a. variances indicating that the growing condition had significant influence on the magnitude of g.c.a. and s.c.a. variances (Table 1).

The results of the predictability ratio was computed to assess the relative magnitude of two variances. The

*Present address: Project Directorate for Cropping Systems Research. Modipuram, Meerut 250 110

Table 1. Analysis of variance for combining ability for various physiological parameters and yield

Source of variance	D.F.	Bio. Recv.	W.U.E.	Yield stab.	T.L.A.	D.R.	Leaf temp.	Transpiration	R.W.C.	Biomass/ plant (g)	Yield/ plant (g)	Trans. Coeff.
Pot condition												
G.C.A.	8	135.27	34.28	48.26	2715887.0	14.58	1.59	16.85	220.93	1905.7	357.6	0.034
S.C.A.	36	219.45	27.70	180.79	366237.60	5.39	1.22	4.15	30.50	429.8	113.4	0.024
Error	44	42.04	9.087	1.16	214475.40	3.87	0.58	2.25	32.35	387.2	398.3	0.024
$\frac{2\sigma^2\ gca}{2\sigma^2\ gca + \sigma^2\ sca}$		−0.09	0.06	−0.15	0.73	0.52	0.09	0.54	1.05	0.81	−0.18	0.72
Irrigation												
G.C.A.	8				32877.7	8414.3	3.87	1.24	64.80	8.87	0.93	
S.C.A.	36				19030.8	6050.9	3.96	0.49	46.38	17.48	4.14	
Error	44				13682.4	3482.9	0.56	0.49	26.65	6.72	1.81	
$\frac{2\sigma^2\ gca}{2\sigma^2\ gca + \sigma^2\ sca}$					0.31	0.14	0.004	1.00	0.14	−0.17	−0.33	
Drought												
G.C.A.	8				24169.7	5.36	1.30	5.65	47.81	33.44	4.36	
S.C.A.	36				31183.0	4.58	0.95	5.85	22.43	31.01	6.71	
Error	44				6647.1	1.63	0.36	3.46	17.69	3.80	2.18	
$\frac{2\sigma^2\ gca}{2\sigma^2\ gca + \sigma^2\ sca}$					0.05	0.04	0.09	−0.01	0.49	0.02	0.10	

Table 2. Estimates of gca effects of parents for drought tolerance characters under irrigated (I) and drought (D) conditions

			MCU5	SRT1	B1007	Laxmi	Reba Pvt 9	Reba B 50	1301 DD	170 Co_2	ACALA SJ 2
Total leaf area	gca	I	3.0	−110.7**	40.7	43.2	−9.3	−48.7	−12.8	69.8*	24.6
		D	−96.1*	8.1	71.9**	−4.1	31.9	25.7	−29.7	11.7	−19.4
	Mean	I	448.4	383.2	660.1	797.8	324.1	392.5	529.9	537.1	537.0
		D	264.1	584.3	694.3	912.4	690.7	865.1	582.9	668.6	401.3
Diffusive resistance	gca	I	−18.8	−33.6	48.3**	30.3	−4.3	−33.5	−12.3	−10.1	13.7
		D	0.4	−0.9	0.1	1.4**	−0.5	−0.7*	−0.6	0.4	−0.2
	Mean	I	110.3	42.6	31.2	74.6	−16.6	16.6	35.2	73.1	30.9
		D	2.4	5.6	2.7	12.5	4.3	3.2	2.9	5.2	2.3
Leaf temp	gca	I	−1.0*	−0.4*	0.8**	0.6*	−0.1	0.0	0.3	−0.4	0.01
		D	0.3*	−0.6**	−0.1	0.1	−0.0	−0.2	−0.1	0.4*	−0.3*
	Mean	I	34.3	34.6	34.6	34.4	34.2	34.2	34.3	34.5	34.4
		D	32.1	31.8	32.0	32.9	32.4	32.4	32.3	33.2	32.7
Transpiration	gca	I	0.5*	0.2	−0.2	−0.5*	−0.3	0.2	0.0	−0.2	0.2
		D	−0.9	0.4	−0.5	−0.8	0.7	0.9	0.4	−0.4	0.3
	Mean	I	1.2	10.6	0.7	0.6	1.4	1.9	0.6	1.2	1.0
		D	8.2	3.2	5.6	1.4	4.0	5.1	5.5	3.7	6.8
R.W.C.	gca	I	2.1	−3.5*	−2.4	−2.5	2.3	−0.5	0.01	1.6	2.9*
		D	−1.7	0.8	−4.3**	1.1	2.1	1.8	−1.0	0.1	1.1
	Mean	I	60.3	55.9	49.4	49.8	69.9	65.0	59.1	74.5	61.6
		D	83.7	85.3	82.5	89.8	92.7	92.8	84.4	90.2	85.4
Bio-mass/ plant	gca	I	−0.0	−1.7*	0.6	1.1	−0.7	0.8	0.2	−0.3	0.1
		D	−0.2	0.6	0.0	2.9**	0.6	0.1	−0.3	−0.1	−3.8**
	Mean	I	19.2	25.0	32.1	29.2	16.5	24.2	23.6	17.2	21.6
		D	27.9	36.7	38.9	44.7	45.6	37.7	34.7	34.1	22.8
Yield/plant	gca	I	−0.0	0.0	−0.4	−0.1	0.3	−0.1	0.2	−0.3	0.4
		D	0.3	0.1	−1.0*	−0.3	0.5	0.1	−0.3	−0.5	1.1*
	Mean	I	5.0	6.5	3.5	3.5	6.5	4.0	3.0	4.5	6.5
		D	9.0	9.5	5.5	6.0	10.5	6.5	5.0	7.5	11.5

*Significant at P = 0.05; ** Significant at P = 0.01

Table 3. Estimates of s.c.a effects for drought tolerant characters under the different sowing conditions for two top crosses from the diallel cross

		T.L.A.	D.R.	L.T.	Trans.	R.W.C.	Biomass/ plant	Yield/ plant	Per se performance
SRT 1 × B1007	I	48.33	−60.44	−2.316**	0.040	0.770	2.357	1.750	7.00
	D	166.36*	−1.29	1.530**	2.270**	−6.593	−2.446	3.182*	12.00
	F	211.95	−3.80*	−0.894	3.741**	−6.928	2.276	−9.028	30.00
SRT 1 × REBA	I	−85.34	−32.10	0.834	−0.790	−7.680	3.530	0.930	7.00
Pvt 9	D	−162.20*	0.11	1.290*	0.270	−1.132	−1.915	5.636**	16.00
	F	−732.85	0.83	0.643	−1.685	−2.706	−1.328	19.999**	66.20
B1007 × 1301DD	I	40.02	18.12	0.984	1.360*	−0.700	0.220	3.570**	9.00
	D	−173.78*	−1.19	−0.950	1.600**	2.738	−4.054*	3.136*	11.50
	F	−48.26	1.08	1.615**	−3.110*	−3.284	−16.465	2.017	49.80
LAXMI × REBA	O	−149.78	−8.83	1.865**	−0.070	0.680	−2.060	2.020	8.00
Pvt 9	D	−296.92**	−2.83*	−0.910	2.860**	6.091	−1.071	0.682	10.50
	F	492.52	−2.12	0.684	2.060	1.350	40.399*	11.817*	69.80
LAXMI × REBA	I	−222.18*	4.58	3.920*	−0.400	−2.360	−1.281	0.480	6.00
B 50	D	−94.39	−2.24	−0.390	0.940	−0.976	1.613	5.591**	15.00
	F	−268.88	−1.05	−0.548	−0.165	−0.316	−3.546	−0.473	57.00
REBA B 50 ×	I	−84.78	−23.88	−1.785*	0.190	−5.740	−1.562	3.660**	9.00
170CO2	D	99.18	2.29	0.990	−1.020	0.254	−5.090**	5.273**	14.50
	F	−827.39	3.47	1.829*	−4.605**	−2.732	3.549	2.699	51.00
1301DD ×	I	93.00	−45.68	1.129	0.830	7.150	6.240*	3.890**	9.50
170C02	D	−210.96*	−1.08	0.249	1.170*	0.047	5.109**	2.182	11.00
	F	160.52	−1.61	−0.457	3.790*	2.020	6.629	7.127	53.80
MCU 5 × ACALA	I	−146.95	−47.33	−0.475	0.620	12.420*	0.360	1.930	8.00
SJ 2	D	284.96**	−0.89	−0.070	0.810	4.364	10.985**	0.909	12.00
	F	538.47	0.08	0.329	−0.345	−4.077	−3.251	14.925*	48.90
LAXMI × ACALA	I	56.20	−63.90	0.840	−0.160	−9.59*	4.56	1.43	7.50
SJ 2	D	67.00	−0.56	0.550	1.120*	−4.82	0.12	0.63	11.00
	F	-	−2.49	−1.450*	2.430	−1.31	−3.45	13.50*	55.30
REBA B 50×	I	69.25	2.97	−0.112	−0.080	−2.840	0.015	1.200	7.00
1301DD	D	−88.72	−0.53	−0.010	1.990**	−0.489	−3.240	1.000	10.50
	F	−291.11	−0.93	0.570	3.069*	1.339	21.735	4.050	58.10

*Significant at P = 0.05, **Significant at P = 0.01

results revealed that additive gene action was showing greater importance in the inheritance of total leaf area, diffusive resistance, transpiration rate, relative water content, biomass per plant and transpiration coefficient under pot condition. Pedigree method of selection would be useful for accumulation of desirable genes in that particular growing condition. Nonadditive gene effects were more important for the remaining characters.

The estimates of g.c.a. effects revealed that none of the parents had good general combining ability for all the traits studied. Analysis of mean performance of the parents and their g.c.a. effects (Table 2) revealed that *per se* performance of the parents is a good reflection of their respective g.c.a. effects. Out of the ten parents tested. Laxmi, Reba Pvt. 9, Reba B-50 and 1301 DD were good general combiners for yield, biomass per plant, relative water content and total leaf area. These parents can be involved in crosses for improving the above characters so that the segregants obtained in the subsequent generation can be selected.

The crosses showing positive and significant s.c.a. effects for various traits are listed in Table 3. None of the cross combinations were observed to be superior for all the traits under study. Cross SRT 1 × B 1007, SRT 1 × Reba Pvt. 9, B 1007 × 1301 DD, Laxmi × Reba B 50, Reba B-50 × 170 CO_2 and 1301 DD × 170 CO_2 were identified as the best cross combinations which could give higher yield with less biomass production. This could be attributed due to reduction in total leaf area under drought. However, these crosses showed less diffusive resistance and high transpiration under rainfed as compared to the irrigated condition, thereby diverting maximum amount of its photosynthates towards end product i.e. kapas yield instead of vegetative growth under such conditions that resulted in better water use efficiency. These crosses also had positive s.c.a. effect for yield under irrigated condition, but it was highly significant for B 1007 × 1301 DD, Reba B 50 × 170 CO_2 and 1301 DD × 170 CO_2 showing positive s.c.a effects for total leaf area and biomass per plant. This indicates that these crosses tend to perform better if grown under better management condition and can be identified as a theoretical ideal genotype.

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