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Improvement of *G. arboreum* cotton for fibre quality traits *vis-a-vis* seed cotton yield under north Indian conditions

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ABSTRACT : More than 90 per cent area is under *Bt* hybrids (*Gossypium hirsutum* and a very less area is under *G. arboreum* cotton. The main reason of less area is labour involved in picking of seed cotton as in *G. arboreum* 2-3 sometimes 4 pickings are required and more importantly the shattering of seed cotton. The *G. arboreum* cotton known as *desi* or diploid cotton which are coarser type particularly in north cotton growing zone of India. For its improvement programme, the primary objective is to enhance the fibre yield per unit area vis-a-vis its quality. In the present study the local well adapted and high yielding but coarse genotypes (LD 327and RG 8) of north India and long linted cultures (CINA 323B, PA 255, PA 304, DLSA 8, CINA 316, PA 464 and DLSA 16) from Central and South India under TMC MM I (2002-2007) programme were intercrossed to develop genotypes with high yield and superior fibre quality. Selections were made in F_2 and further selections resulted in identification of ten genotypes viz., CISA 6-350, CISA 6-295, CISA 6-209, CISA 6-256, CISA 33-1, CISA 33-2, CISA 33-3, CISA 33-6, CISA 33-7 and CISA 33-8 and after stabilization over the years, they were evaluated for seed cotton yield and quality traits for three years (2014-2016). On three years mean basis there was improvement in UHML 13.17-23.37 per cent to 20.5-25.3 mm and seed cotton yield of one genotype CISA-33-3 (2552.1 kg/ha) was recorded significantly superior than the check variety CISA 614 (2348.0 kg/ha) and another genotype CISA 33-1 (2221.1 kg/ha) could gave seed cotton yield *at par* with the check variety. There was an improvement of 8.25-22.20 per cent in bundle strength (g/tex) and reduction in MIC of 4.25-20.19 per cent, increase in fineness.

Key words: Fibre quality traits, *G. arboreum* cotton, Improvement, seed cotton yield

Cotton is an important fibre crop and is a major source of seed oil and protein, is cultivated in more than 75 countries around the world. *G. hirsutum* covers more than 90 per cent of acreage while the diploid the least (Verma *et al.*, 2020). The diploids are relatively tolerant to insect-pest and diseases and require less inputs as compared to *G. hirsutum*. The cotton leaf curl disease is prevalent in *G. hirsutum* and no genotype is immune to this disease, however, diploid cotton *G. arboreum* is observed to be immune to this dreaded disease. For any cotton improvement programme, the primary objective is to enhance the fibre yield/unit area and its quality. Before 1980s the seed cotton yield of *G. arboreum* in North India was about 10q/ha (Table 1), it was improved to 20q/ha or more in 1990s. Interestingly in Central India where the maturity was 180-200 or even more few genotypes like AKH 4, AKA 8401, PA 183 etc. were developed with MHL of 24-27 mm having spinning count of even 40s equivalent to *G. hirsutum* (Chandra and Sreenivasan, 2011). In north India, the main reason of less area is more 2-3 even more pickings are required and shattering problem. But there is potential of higher seed cotton yield even upto 35q/ha, can be combined with good fibre quality even if some yield is foregone which may compensate in terms of remuneration (if good fibre quality is purchased at higher rate), hence the future for good quality high yielding arboreum cotton.

MATERIALS AND METHODS

In the present study the local well adapted and high yielding but coarse genotypes (LD 327and RG 8) of north India and long linted cultures (CINA 323B, PA 255, PA 304, DLSA 8, CINA 316, PA 464 and DLSA 16, (Table 2) from Central and South India under TMC Mini Mission programme (2002-2007) were intercrossed to develop genotypes with high yield and superior fibre quality. The crosses attempted were evaluated and increase in fibre quality was observed in F_1s (Table 3). Ten genotypes viz., CISA 6-350, CISA 6-295, CISA 6-209, CISA 6-256, CISA 33-1, CISA 33-2, CISA 33-3, CISA 33-6, CISA 33-7 and CISA 33-8 (Table 4) were identified which were stabilized and evaluated for three years (2014-2016) for seed cotton yield and quality traits. Genotypic correlation was computed as per method suggested by Robinson *et al.*, (1951). The path analysis was carried out as per the method suggested by Wright (1921) and Dewey and Lu (1959).

RESULTS AND DISCUSSION

In cotton, fibre or lint is the main product. Fibre quality includes fibre length, strength, fineness, maturityand uniformity. The genotypes namely PA255,PA304,PA464, DLSA8, DLSA16, CINA316 and CIN323B were evaluated at CICR, RS, Sirsa farm and the fibre quality ranges were recorded as;for GOT (%) 32.5 to 36.8, fibre length 23.8 to 26.7 mm, fibre strength 20.1 to 24.0 g/tex, MIC 4.8 to 5.5 (Table 2). These genotypes were crossed with RG8 and LD327 the ruling *G. arboreum* varieties of north zone and the F_1s were evaluated (Table 3). Only one F_1 RG8 x CINA316 could out yield significantly over best local check variety RG8. For fibre traits ranges were obtained as; for GOT (%) 30.1 to 36.5, for fibre length 20.1 to 26.4 mm, for strength 14.2 to 21.3 g/tex and MIC 5.2 to 7.7, respectively. Single plant selections were made based on fibre quality and seed cotton field. They were advanced to progeny row trials. Later they were stabilized. After stabilization these selections were evaluated over 3 years in RBD and mean values were subjected to analysis.

There was 13.17- 23.37 per cent improvement in UHML (20.5-25.3 mm) and seed cotton yield of one genotype CISA-33-3 (2552.1 kg/ha) was recorded significantly superior than the check variety CISA 614 (2348.0 kg/ha) and another genotype CISA33-1 (2221.1 kg/ha) could gave seed cotton yield at par with the check variety (Table 4). There was an improvement of 8.25-22.20 per cent in bundle strength (g/tex) and reduction in MIC of 4.25- 20.19 per cent, increase in fineness.

Genotypic and phenotypic correlations for seed cotton yield and fibre quality traits are presented in Table 5. Genotypic correlation coefficients in general were higher than phenotypic correlation coefficients (Table 5). Seed cotton yield/plant was significantly and positively correlated with lint yield, and Micronaire value at phenotypic level, whereas with lint yield, boll size and MIC at genotypic level. Apart from MIC seed cotton yield showed negative significance for

Table 1. Genotypes of north India

Name	Place	Year of release	Seed cotton yield (q/ha)	GOT (%)	Fibre length (mm)	MIC	Strength
DS-1	HAU	1985	20.0	39.2	17.0	7.7	-
DS-5	HAU	1989	20.5	40.1	17.5	7.0	-
HD-107	HAU	1996	26.0	38.4	18.6	8.0	-
HD-123	HAU	2000	22.9	39.0	14.7	7.0	14.6
HD-324	HAU	2005	18.6	41.6	17.8	7.4	16.4
HD-432	HAU	2010	21.4	39.3	21.2	7.0	17.6
G-27	PAU	1973	10	37	16	-	-
LD-327	PAU	1989	20	41	16	7.0	-
LD-491	PAU	1996	14	39	20	-	-
LD-694	PAU	-	23.2	36.1	20.7	7.1	16.3
RG-8	RAU, SGN	1988	17	39	19	6.9	18.3
RG-18	RAU, SGN	2001	24	38	-	-	-
CISA-614	CICR, SRS	2010	22	36.6	20.9	6.8	16.9
CISA-310	CICR SRS	2010	21.7	36.5	20.2	7.1	15.9

Table 2. Performance of genotypes of central India under north conditions at CICR, Regional Station, Sirsa

Name	Place	Seed cotton yield (kg/ha)	GOT (%)	Fibre length (mm)	MIC	Strength (g/tex)
PA 255	Parbhani	538.2	36.8	26.0	5.4	22.1
PA 304	Parbhani	560.3	36.1	26.7	4.8	22.3
PA 464	Parbhani	452.8	34.9	26.0	5.3	20.1
DLSA 8	Dharwad	705.0	34.3	25.5	4.8	22.7
DLSA 16	Dharwad	590.7	34.8	23.9	4.9	21.1
CINA 316	Nagpur	669.0	35.6	23.8	5.0	22.9
CINA 323B	Nagpur	849.8	32.5	25.1	4.9	24.0

Table 3. Crosses attempted

Entry	Seed cotton yield (Kg/ha)	Boll wt (g)	GOT (%)	Fibre length (mm)	MIC	Strength (g/tex)
LD327 x PA 255	1461.1	2.3	34.8	24.1	7.1	18.6
LD327 x CINA-316	737	2.7	34.9	25.2	7	18.4
RG-8 xCINA316	2586.4	2.7	33.4	25.5	7.2	19.6
RG-8 x PA255	1338.5	3.0	35.9	24.1	7.5	17.2
RG-8 x PA304	1718.8	3.0	30.1	24.8	7.7	17.3
LD327 x DLSA-16	1851.1	2.5	34.9	25.1	7.5	14.2
HD-123 x DLSA-8	1195.1	2.8	35.0	25.3	7.6	17.5
RG-8 x PA304	1574.0	2.6	36.0	24.3	6.8	18.7
DLSA-16 x RG-8	2314.8	2.7	33.5	24.2	7.1	20.4
PA464 x RG-8	2037.0	2.4	33.5	26.4	5.2	21.3
PA304 xLD327	1203.7	2.5	35.5	24.4	6.8	18.3
PA304 x HD123	1481.4	2.0	35.5	24.4	5.3	17.9
CINA323BxHD123	1555.5	2.3	36.5	25.2	6.2	18.2
PA25 x HD123	666.6	2.3	33.5	24.1	6.7	19.3
PA255 x LD 327	1555.5	2.6	36.5	20.1	5.6	16.7
CISA-33 x PA304	740.7	1.6	34.5	23.6	6.1	19.2
HD-123 (LC)	2086	3.2	36.9	20.2	7.0	16.2
RG-8 (LC)	2237.6	2.5	38.0	17.3	7.0	14.8

CV% = 12.42 CD (kg/ha) = 194.62

Table 4. Mean performance of improved genotypes over 3 years (2014-16)

Entry	Seed cotton yield (Kg/ha)	Lint yield (kg/ha)	GOT (%)	Boll wt (g)	UHML (mm)	(%) IOC	UR	Strength (g/tex)	(%) IOC	MIC	(%) IOC
CISA 6-350	1,737.6	674.2	38.7	2.0	25.7	26.0	80.7	24.9	18.9	6.7	-7.40
CISA 6-295	1,741.4	653.5	37.4	2.0	26.1	28.0	80.8	25.7	22.4	5.6	-22.2
CISA 614 (check)	2,348.0	896.6	38.1	2.0	20.4	0.0	77.7	21.0	0.0	7.2	0.0
CISA 6-209	1,657.8	633.3	38.2	2.0	24.4	20.0	80.4	25.1	7.0	5.5	-23.2
CISA 6-256	1,523.8	592.6	38.9	1.9	23.5	15.4	80.5	24.1	14.9	6.6	-8.3
CISA 33-1	1,848.7	712.9	38.7	2.0	24.5	20.3	80.0	19.4	-7.5	5.4	-25.0
CISA 33-2	2,221.1	850.0	38.2	1.9	23.3	14.4	79.0	18.4	-12.3	6.5	-9.7
CISA 33-3	2,552.1	957.3	37.5	2.0	23.5	15.4	79.9	19.6	-6.5	6.6	-8.3
CISA 33-6	1,754.6	655.1	37.2	1.8	25.8	26.7	80.0	20.4	-2.7	5.3	-26.4
CISA 33-7	1,736.0	677.6	39.0	2.0	25.3	24.2	80.3	19.8	-5.6	5.3	-26.4
CISA 33-8	1,971.6	756.9	38.4	1.9	25.7	26.18	81.1	20.0	-4.6	6.0	-16.7
CD	413.30	171.89									
CV (%)	12.94	14.08									

% IOC = Percent Increase Over Check

UHML, Fiber strength, uniformity ratio and GOT at both phenotypic and genotypic level. For lint yield positive phenotypic correlation was observed with GOT and MIC whereas positive and significant genotypic correlation was found with boll weight and MIC. Similar trend for lint yield

Table 5. Genotypic and phenotypic (above diagonal) correlation for seed cotton yield and fibre quality traits

	SCY (kg/ha)	Lint yield (kg/ha)	GOT (%)	Boll wt (g)	UHML (mm) (g/tex)	UR	Strength	MIC
SCY(kg/ha)		0.994**	-0.001	-0.108	-0.500**	-0.506**	-0.454**	0.383*
LY(kg/ha)	1.001**		0.107	-0.105	-0.504**	-0.495**	-0.448**	0.380*
GOT (%)	-0.879**	-0.878**		0.045	-0.062	0.096	0.024	0.012
Boll wt (g)	0.913**	1.092**	1.867**		-0.093	0.117	0.186	0.019
UHML (mm)	-0.651**	-0.698**	-0.093	-1.134**		0.556**	0.270	-0.614**
UR	-0.821**	-0.871**	0.165	-1.746**	1.322**		0.249	-0.433*
Strength	-0.694**	-0.740**	-0.049	1.737**	0.235	0.655**		0.009
MIC	0.659**	0.718**	0.196	0.225	-0.764**	-0.654**	0.019	

Table 6. Path analysis

	Lint yield (kg/ha)	GOT (%)	Boll wt (g)	UHML (mm)	UR	Strength (g/tex)	MIC	Gen. Cor. SCY
LintYield(kg/ha)	1.0053	-0.0116	-0.0003	-0.0008	-0.0016	0.0011	0.0018	1.001**
GOT (%)	0.1071	-0.1089	0.0001	-0.0001	0.0003	-0.0001	0.0001	-0.879**
Boll wt (g)	-0.1056	-0.0050	0.0030	-0.0001	0.0004	-0.0005	0.0001	0.913**
UHML (mm)	-0.5066	0.0068	-0.0003	0.0015	0.0018	-0.0007	-0.0029	-0.651**
UR	-0.4973	-0.0104	0.0004	0.0008	0.0033	-0.0006	-0.0020	-0.821**
Strength	-0.4508	-0.0026	0.0006	0.0004	0.0008	-0.0024	0.0000	-0.694**
Mic.	0.3822	-0.0013	0.0001	-0.0009	-0.0014	0.0000	0.0047	0.659**

Residual error: 0.00062

Table 7: Genetic component of variance for seed cotton yield and important yield components

	Overall mean	h^2	GCV	PCV	Genetic gain over Mean
Seed Cotton Yield (kg/ha)	1,917.52	57.35	15.01	19.82	23.41
Lint Yield (kg/ha)	732.74	49.61	13.98	19.84	20.28
GOT %	38.21	23.45	1.13	2.32	1.12
Boll wt (g.)	1.95	1.38	0.69	5.89	0.17
UHML (mm)	24.38	88.37	6.71	7.14	13.00
UR	80.03	22.93	0.82	1.72	0.81
Strength	21.67	91.94	12.28	12.80	24.25
MIC.	6.06	78.57	10.62	11.99	19.40

was found as of seed cotton yield. Positive phenotypic and genotypic correlation with Significant and positive correlations were also observed between component traits as well like UHML showed positive and significant with respect to both genotypic and phenotypic correlation with UR and Uniformity ratio showed positive significant genotypic correlation with UHML and Fiber strength whereas positive significant phenotypic relation with UHML. Fiber strength has positive and significant genotypic correlation with boll weight and UR and Boll weight showed positive significance for GOT and Fiber strength. Similar results were also reported by Hafiz *et al.*, (2013) and Rajanna *et al.*, (2011).

The estimates of correlation coefficient mostly indicated inter-relationship of different traits, but it did not furnish information on cause and effect. Under such situation path analysis helps the breeder to identify the index of selection. Path coefficient analysis was done in order to study the direct and indirect effects of individual component characters on the dependent variable *i.e.*, seed cotton yield/plant. Study of path coefficients enable the breeders to concentrate on the variables which show high direct effect on seed cotton yield. The genotypic and phenotypic correlation coefficients of seed cotton yield with other yield and fiber quality traits was further partitioned into direct and indirect effects and the results were presented in Table 6. The component of residual effect of path analysis in yield and fiber quality traits is 0.0062 at genotypic level. The lower residual effect indicated that the characters chosen for path analysis were adequate and appropriate.

Path coefficient analysis indicated that lint yield per plant, boll weight, UHML, UR and MIC had shown direct positive effect on seed cotton yield/plant at genotypic level. The indirect positive effect on seed cotton yield/plant at genotypic levels were observed through boll weight with GOT, uniformity ratio and MIC; through uniformity ratio with GOT, boll weight, UHML and fiber strength; through MIC with lint yield, GOT and boll weight; through lint yield with GOT and MIC; through UHML with uniformity ratio and fiber strength, andthrough fiber strength with lint yield and GOT with UHML. For lint yield the correlation coefficient and direct effect are equal in magnitude showing its perfect correlation with seed cotton yield. GOT the direct effects had higher magnitude than correlation with negative directions indicating negative correlation with seed cotton yield whereas for fiber strength the magnitude of correlation was more than direct effects with reverse direction to seed cotton yield. For boll weight, UHML, uniformity ratio and MIC the magnitude of correlation coefficient was much higher than their direct effects with similar direction to seed cotton yield which suggests that the improvement in these traits can get positive improvement for seed cotton yield but the role of indirect effects also needs to be considered carefully. Hence, from the correlation and path coefficient analysis study it was inferred that, Lint yield has perfect positive correlation with the seed cotton yield whereas the other fiber traits show positive direction, but the role of indirect effect play significant role during the simultaneous improvement of the traits.

The phenotypic (rp) and genotypic correlation coefficients (rg) indicate that plant height had positive and complete association with number of bolls (rp = 0.581, rg = 0.982) and seed cotton yield (rp = 0.590, rg = 1.00), the coefficients being significant at genotypic and phenotypic levels (Table 2). Number of bolls showed positive and significant correlation with seed cotton yield at both the levels (rp = 0.968, rg = 1.00) and again the relationship appeared to be strong. However, plant height was found to be negatively and non-significantly correlated with boll weight and lint percentage. Association among bolls, boll weight and lint percentage were negative and similarly boll weight and lint percentage were found to have negative association with seed cotton yield (Table 2). The estimates of broad sense heritability of the characters varied from low to moderate (Table 3). For bolls it is 38 per cent, followed by plant height (35%), seed cotton yield (33%), lint percentage (23%), and for boll weight the estimate was the lowest (22%).

The estimate of heritability (h2), genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV) and genetic gain (GG) are presented in Table 7. It is apparent from the table that phenotypic coefficients of variation were invariably greater than the corresponding genotypic coefficient of variation though the trend of both GCV and PCV was same. The parameter-wise findings are as follows: GCV and PCV was high for seed cotton yield (15.01, 19.82), lint yield (13.98, 19.84), fiber strength (12.28, 12.8) and MIC (10.62, 11.99) whereas both GCV and PCV were low for other four traits under study *i.e.* GOT (1.13, 2.32), boll weight (0.69, 5.89), UHML (6.71, 7.14) and uniformity ratio (0.82, 1.72). Heritability was high for fiber strength (91.94), UHML (88.37), MIC (78.57) and Seed cotton yield (57.35). Medium (between 20 to 50) heritability was observed for lint yield (49.61), GOT (23.45) and uniformity ratio (22.93). Heritability estimates were found very low for boll weight (1.38). Genetic gain was recorded high for fiber strength (24.25), seed cotton yield (23.41), lint yield (20.28), MIC (19.4) and UHML (13.0), whereas it was observed low for GOT (1.12), uniformity ratio (0.81) and boll weight (0.17).

High genetic gain was achieved during this study for fiber traits *i.e.* lint yield, fiber length, fiber strength and MIC value. A negative significant genotypic and phenotypic correlation was observed among seed cotton yield, UHML and bundle strength but the direct effects from UHML and bundle strength was positive, under such circumstances a restrictive model should be followed (Singh and Kakar,1977). Further during path analysis, it was found that there was negative contribution of UHML and bundle strength towards seed cotton yield. For boll weight and all the three fiber traits the magnitude of correlation coefficient was much higher than their direct effects indicating the importance of indirect effects which suggests that the improvement in these traits can pull positive improvement for seed cotton yield with judicious consideration of indirect effects. From the correlation and path coefficient analysis study it was inferred that, Lint yield has perfect positive correlation with the seed cotton yield whereas the other fiber traits show positive direction, but the role of indirect effect play significant role during the simultaneous improvement of the traits.

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