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Research Article

Assessment of yield components and fibre quality traits in an introgressed population derived from *Gossypium hirsutum* and *G. barbadense*

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Abstract

The introgressed populations developed from crosse between *Gossypium hirsutum* and *G. barbadense* were used to assess genetic variation for yield components and fibre quality traits. A difference among introgressed lines and parental lines was significant for all traits except sympodial branches, node number, uniformity index and fibre elongation. The lines with high ginning outturn showed higher values for plant height, seed index and lint index than the lines with cluster boll bearing, round boll lines and fibre length-strength lines. However, the majority of introgressed lines had lower values for boll number and seed cotton yield as compared to the parental lines Suraj and NH 615. For fibre strength and ginning outturn, the lines *viz*., CNH 31-90 and CNH 29-90 had higher fibre strength of 30.5 and 30.1 g/tex, respectively. CNH 19-5 (35.8 mm) and CNH 19-4 (33.9 mm) showed higher values for fibre length which was significantly higher than the variety Suraj (31.6 mm). Similarly, CNH 29-90 (30.1 g/tex), CNH 31-90 (30.5 g/tex) as well as CNH 19-4 and CNH 42-6 (29.9 g/tex) displayed higher values for fibre strength. Lines *viz.,* CNH 44-31, CNH 47-31, CNH 19-4, CNH 19-5 and CNH 42-6 were identified for a desirable combination of yield and fibre quality and ginning percentage. CNH 31-90, CNH 33-94 and CNH 48-4 had a combination of fibre quality and high ginning percentage. In the majority of lines, the mean values for fibre length and strength were the most biased towards the *G. hirsutum* variety Suraj and NH 615. Fibre quality traits *viz*., length and strength, were highly and positively correlated (0.41) suggesting that selections can be made for simultaneous improvement of fibre length and strength. Fibre length (-0.04) and fibre strength (-0.06) had a lesser negative association with seed cotton yield indicating breaking of strong negative correlation between yield and quality (either length or strength) in interspecific lines between *G. hirsutum* and *G. barbadense*.

Key words*:* Correlations, Fibre quality, *G. barbadense*, Introgression lines, Yield components, Upland cotton

INTRODUCTION

Cotton (*Gossypium spp.*) is one of the world's leading textile fibre crops. The genus *Gossypium* includes 46 diploid (2*n* = 2×= 26) and 7 allotetraploid (2*n* = 4× = 52) species (Fang *et al*., 2017). The representatives of the genus *Gossypium*, fall into four subgenera *Gossypium* (A, B, E, F genomes), *Sturtia* (C, G, K genomes), *Houzingenia* (D genome) and *Karpas* (AD genomes) (Strygina *et al*., 2020). Of the four subgenera, *Karpas* constitutes two tetraploid cultivated species, *G. hirsutum* and *G. barbadense* which occupy the largest area under cultivation worldwide. These two species differ significantly in their fibre properties, *G. barbadense* is having much longer, finer and stronger fibres than *G. hirsutum*, however, *G. hirsutum* had wider adaptability and high yield potential. *G. barbadense* is grown only in limited areas due to its relatively low yield and narrow adaptation.

There have been numerous successful introgression reports on the development of series of introgression lines carrying desirable traits from interspecific crosses between *G*. *hirsutum* and *G*. *barbadense* cotton (Davis 1978, May 2001, Yuan *et al*., 2000, Zhang 2011, Zhang *et al*., 2012, Jenkin *et al*., 2013, Yu *et al*., 2013, Zeng *et al*., 2016, Song *et al*., 2017, Saha *et al*., 2017, Martinez *et al*., 2018, Brown *et al*., 2019). In India, breeding efforts in the development of *G. barbadense* cultivars led to the release of Sujata (1969) and Suvin (1976) which is a significant breakthrough in fibre quality improvement. These varieties are capable of spinning 100-120 counts and are comparable to several Pima, Egyptian and Sudan types. In the present investigation, efforts were intended to combine the technological qualities of the *G. barbadense* var. Suvin and agronomic qualities of *G. hirsutum*. Interspecific population developed between *G*. *hirsutum* and *G*. *barbadense* through backcrosses, three-way and four-way crosses were evaluated for yield components and fibre quality traits. The extent of genetic variability generated, the relationship of yield components and fibre quality traits and identification of promising superior progenies has been discussed.

MATERIALS AND METHODS

An interspecific crossing programme was undertaken involving *G*. *barbadense* (Gb) and *G*. *hirsutum* (Gh) species. In this study, a backcross inbred lines (BIL) was developed involving *G*. *hirsutum* cv. Suraj as a recurrent parent and *G*. *barbadense* cv. Suvin as a donor through one generation of backcrossing followed by four generations of self pollination (for ginning outturn lines, GOT lines). Suvin is a derivative of a cross between Sujata and Sea Island cotton St. Vincent, which is considered as one of the finest cotton varieties produced in India and is comparable to Egyptian Giza 45 and American Pima extra-long cotton. The variety Suraj, released in 2008, was developed from a three-way cross of LRA 5166 × (CCH 526612 × HLS 329) and is known for superior fibre qualities. Suraj is extensively used as a quality check in multilocation trials conducted under ICAR-All India Coordinated Research Project on Cotton in India. Three-way crosses (Suraj×Suvin) x IC 356793 and (NH 615 ×Suvin) x G-21-19-619 were used to develop cluster boll bearing lines (CBL) and round boll lines (RBL), respectively. Fibre length-strength lines (LSL) were developed using a four-way cross (NH615 × Suvin) x (Suraj × CCH 4474).

Sixteen BC_1F_5 high ginning outturn (GOT) progenies, 12 F_5 three-way cluster and round boll progenies and nine F_5 four-way cross length-strength progenies were evaluated in completely randomized block design with two replications for agronomic and fibre quality traits during 2019-20 at ICAR-Central Institute for Cotton Research, Nagpur. These lines were differentiated as ginning percentage lines (1-16), cluster boll bearing lines (17-22), round boll bearing lines (23-28) and fibre length-strength lines (29-37) (Table 1). The size of the block was of a single row with 4.5 m length, spaced 0.45 m between plants and 0.6 m between rows. Recommended agronomic practices were followed for raising a crop at ICAR-CICR, Nagpur. The observations were recorded for plant height (PH), the number of monopodia (MO), the number of sympodial branches (SY), the number of bolls per plant (BN), boll weight (BW), ginning outturn (GOT), lint index (LI) and seed index (SI). The lint of individual progenies was tested for fibre quality traits using a High volume instrument (HVI) at ICAR-Central Institute for Research on Cotton Technology, Mumbai in HVI mode. Fibre quality traits included upper half mean length (UHML), uniformity ratio (UR), micronaire (MC), fibre strength (FS) and fibre elongation (FE). WASP 2.0 (Web Based Agricultural Statistics Software Package) was used for the analysis of completely randomized block design and correlation analysis.

RESULTS AND DISCUSSION

The mean data on seed cotton yield, yield components and fibre quality traits of the backcross, three-way and four-way cross progenies and parents are presented **(Table 1).** Introgressed and parental lines differ significantly for all traits except sympodial branches, node number, uniformity index and fibre elongation. Introgressed lines had displayed a wide range of variations for most of the traits as compared with both parental varieties. The mean values for ginning outturn, boll weight, seed index and lint index in the introgressed population was higher than the average of the parental varieties. Nie *et al*. (2015) showed that backcross inbred lines (BC_1F_8) derived from *G. hirsutum* and *G. barbadense* had significant variations in plant architecture, seed size, and fuzz colour while plant height, seed index, elongation percentage and fibre length were normally distributed.

Amongst lines, GOT lines showed higher values for plant height, seed index and lint index than the cluster, round boll and length-strength lines. However, these lines had lower mean values for boll number and seed cotton yield as compared to the varieties Suraj and NH 615. CNH 44-31 had the highest seed cotton yield of 69.4 g per plant followed by CNH 45-31 (68.9 g) and CNH 42-6 (68.3 g). GOT lines also had a higher mean boll weight than the CBL, RBL and LS lines. CNH 47-31 had the highest boll weight of 5.6 g followed by CNH 47-31, CNH 50-31 (5.5 g) and CNH 35-94 (5.4 g). Yu *et al*. (2013) reported transgressive segregation in a *Gossypium hirsutum* × *Gossypium barbadense* backcross inbred lines (BIL) and observed normal distribution in yield and fibre quality traits.

Round boll lines *viz.*, CNH 48-6 and CNH 43-4 had the highest ginning per cent of 44.2 and 43.4 per cent, respectively. Similarly, GOT lines *viz.,* CNH 31-90, CNH 33-94, CNH 40-94 and CNH 41-94 had significantly higher ginning per cent values of 41.9, 42.2, 42.4 and 41.6

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Table1. Mean values for seed cotton yield, its components and fibre quality traits of introgressed lines

S. No.	Name of Progeny	HT	MO	SY	NN	BN	BW	GOT	SI	LI	SCY	UHML	UR	MC	ST	FE
High GOT Lines																
1	CNH 29-90	95.9	1.1	22.2	29.4	16.4	2.8	37.9	8.9	5.4	27.9	30.8	85.0	3.9	30.1	6.0
2	CNH 30-90	116.6	0.9	24.9	32.9	16.8	2.8	37.5	10.0	6.0	45.9	31.5	87.0	3.9	29.2	6.0
3	CNH 31-90	89.3	0.9	18.0	27.4	19.5	2.4	41.9	9.4	5.9	16.0	31.4	85.5	3.0	30.5	5.9
4	CNH 33-94	122.9	1.7	22.2	29.6	15.0	5.0	42.2	11.9	8.5	48.1	29.2	84.0	4.5	26.7	5.9
5	CNH 34-94	105.8	2.1	18.1	25.4	15.7	4.9	40.9	11.1	7.6	41.7	30.8	84.5	3.5	26.4	5.8
6	CNH 35-94	134.5	2.1	23.6	32.7	17.9	5.4	40.3	12.0	8.3	54.5	30.6	86.0	4.3	27.8	6.0
7	CNH 37-94	133.7	2.2	24.9	31.4	20.6	5.1	39.0	11.8	7.6	62.0	30.3	85.5	4.3	26.5	5.0
8	CNH 38-94	117.6	1.6	20.5	28.7	18.0	5.6	41.0	11.4	7.9	38.2	29.3	84.0	4.3	26.9	5.8
9	CNH 40-94	136.8	1.9	21.9	30.4	18.0	4.3	42.4	10.7	7.5	56.9	29.2	84.5	4.6	25.4	5.7
10	CNH 41-94	122.1	1.5	22.8	29.8	16.2	5.4	41.6	12.0	8.6	51.8	29.6	85.5	4.2	28.7	5.9
11	CNH 44-31	141.0	2.0	23.7	33.5	24.5	4.0	38.5	10.0	6.3	69.4	29.1	83.5	4.6	27.8	5.8
12	CNH 45-31	131.7	2.8	21.0	29.1	15.7	5.0	40.9	12.7	8.8	68.9	30.7	85.5	4.5	26.6	5.9
13	CNH 47-31	132.3	2.3	21.0	28.9	16.0	5.5	40.3	11.8	8.1	58.8	30.2	85.5	4.2	27.4	5.9
14	CNH 48-31	107.0	2.2	22.2	30.0	18.3	4.6	38.2	11.3	7.2	37.1	30.3	86.0	4.8	27.0	6.0
15	CNH 49-31	136.2	2.0	22.1	33.1	17.0	5.0	40.8	11.8	8.2	25.4	30.3	84.5	4.2	28.4	5.9
16	CNH 50-31	118.1	1.4	22.0	29.1	13.8	5.5	39.9	12.5	8.3	51.3	30.5	85.0	4.5	27.2	5.9
Cluster Boll Bearing Lines																
17	CNH 20-1	98.1	1.9	23.6	31.1	18.1	3.9	33.9	10.4	5.4	34.4	30.1	85.0	5.0	26.2	5.9
18	CNH 20-2	103.1	2.8	19.4	28.4	18.3	4.5	37.9	9.9	6.2	48.2	28.3	84.5	4.8	27.7	5.8
19	CNH 20-3	104.4	2.8	22.9	30.0	19.6	3.9	34.3	11.2	5.8	45.3	28.1	84.5	5.5	28.6	5.5
20	CNH 20-4	98.0	1.7	22.6	29.2	17.0	5.1	35.1	10.0	5.4	43.5	29.3	85.5	5.2	26.5	5.9
21	CNH 20-5	115.6	1.4	22.6	29.9	17.2	4.7	34.0	12.0	6.2	30.0	30.0	85.0	5.2	29.1	6.0
22	CNH 20-6	111.4	0.7	20.6	25.8	25.8	4.1	35.8	8.3	6.3	33.1	29.8	84.5	4.6	27.2	5.8
Round Boll Lines																
23	CNH 48-1	85.8	2.7	25.6	32.6	10.5	3.6	36.8	11.1	6.4	17.6	29.2	84.0	4.6	28.4	5.8
24	CNH 48-2	83.0	1.2	22.4	29.6	15.2	3.6	38.2	9.5	5.9	27.1	29.6	86.0	3.7	26.1	5.7
25	CNH 48-3	111.9	1.3	24.8	17.8	22.2	3.8	40.6	9.2	7.2	40.2	28.9	84.0	4.7	24.9	5.7
26	CNH 48-4	91.2	1.5	24.1	30.5	13.0	3.3	42.0	10.8	8.0	24.3	29.1	86.0	4.4	28.0	5.8
27	CNH 48-5	99.5	1.0	23.6	30.6	15.9	3.6	43.4	9.5	7.4	35.1	29.1	85.5	4.5	26.1	5.7
28	CNH 48-6	88.5	0.7	23.2	29.6	14.9	3.5	44.2	10.4	8.0	37.7	28.5	84.5	4.0.	24.9	5.5
Fibre Length-strength lines																
29	CNH 19-1	92.3	2.0	17.8	25.2	22.4	2.6	38.3	10.4	9.9	18.0	30.0	85.5	3.7	27.8	5.8
30	CNH 19-4	98.8	1.9	21.0	28.2	24.2	3.8	38.2	11.5	8.1	57.1	33.9	84.5	3.5	29.9	5.9
31	CNH 19-5	100.5	2.2	23.7	28.7	26.3	4.0	38.2	12.9	7.1	31.2	35.8	84.0	3.6	28.5	6.0
32	CNH 19-8	100.7	3.4	16.4	24.7	13.9	3.6	33.9	10.9	6.0	25.9	32.5	85.0	3.6	27.9	5.9
33	CNH 19-10	118.8	2.2	24.0	31.0	29.9	3.5	35.5	12.3	6.8	42.5	33.3	86.0	4.3	29.7	6.1
34	CNH 42-6	117.3	0.2	23.8	31.5	26.2	4.2	35.1	9.8	5.3	68.3	28.7	86.0	4.6	29.9	5.9
35	CNH 42-7	118.0	0.3	40.9	28.3	28.3	3.7	36.1	8.7	4.9	54.7	31.3	86.0	4.2	28.4	5.9
36	CNH 42-8	83.3	2.2	16.3	26.7	19.6	3.9	35.9	8.7	4.9	39.1	26.4	85.5	4.9	27.6	5.8
37	CNH 42-10	87.5	0.8	17.4	27.3	21.2	3.3	37.1	8.6	5.1	39.9	28.6	85.5	4.1	28.2	5.8
38	Suraj	121.6	0.3	26.6	32.6	24.2	4.2	35.4	8.9	4.8	69.4	31.6	85.0	4.2	29.6	6.0
39	NH 615	116.4	2.0	27.0	33.1	24.2	4.1	36.0	7.4	4.1	65.1	29.3	85.0	4.0	26.6	5.8
	Mean	109.9	1.7	22.6	29.3	19.2	4.2	38.4	10.6	6.8	43.1	30.2	85.1	4.3	27.7	5.9
	Maximum	141	3.5	40.9	33.5	29.9	5.6	44.2	12.9	9.9	69.4	35.8	87.0	5.5	30.5	6.2
	Minimum	83	2.0	16.3	17.8	10.5	2.4	33.9	7.4	4.1	16.0	26.4	83.5	3.1	24.9	5.5
	CD @ 5%	20.6	1.5	NS	NS	5.9	1.1	4.9	0.7	1.8	26.2	1.99	NS	0.67	2.7	NS

NS = Non-significant, PH = Plant height (cm), MO = Number of monopodia, SY = Number of sympodia; NN = Number of nodes; BN = Boll number per plant; GOT = Ginning outturn (%); BW = Boll weight (g); SI = Seed index (g); LI = Lint index (g); SCY = Seed cotton yield (g); UHML = Upper half mean length (mm); UR = Uniformity ratio (%); MC = Micronaire (µg/inch); FS = Fiber strength (g/tex); FE = Fibre elongation (%)

per cent, respectively than the parental varieties Suraj (35.4%) and NH 615 (36.0%). Fibre LS lines CNH 19-5 and CNH 19-4 had significantly higher fibre lengths of 35.8 and 33.9, respectively than that of parental varieties Suraj (31.6 mm) and NH 615 (29.3 mm). For fibre strength, GOT lines CNH 31-90 and CNH 29-90 had higher fibre strength of 30.5 and 30.1 g/tex, respectively; while in LS lines, CNH 19-4 and CNH 42-6 had fibre strength of 29.9 g/tex followed by CNH 19-10 (29.7 g/tex). The fibre length of these introgressed lines was comparable to varieties Suraj (29.6 g/tex) and NH 615 (26.6 g/tex). Chandnani *et al*. (2018) also found transgressive segregation in BC_4F_1 for all fiber quality traits i. e. upper half mean length, fibre strength, elongation, micronaire and uniformity index in both *G*. *hirsutum* and *G*. *barbadense* backgrounds.

In spite of distinct and large variation for other traits, introgressed lines for fibre length and strength had values that were most biased toward the *G*. *hirsutum* varieties Suraj and NH 615. CNH 19-5 (35.8 mm) and CNH 19-4 (33.9 mm) displayed higher values for fibre length over the check varieties Suraj and NH 615 which had the length of 31.6 and 29.3 mm, respectively. Similarly, CNH 29-90 (30.1g/tex), CNH 31-90 (30.5 g//tex) and CNH 19-4 and CNH 42-6 (29.9 g/tex) displayed higher values for fibre strength. Kannan *et al*. (2011) also obtained high productive interspecific progenies (*Gh*× *Gb*) with high fibre strength that ranged from 30.0 to 35.7g/tex in BC_1F_8 generation. Lacape *et al*. (2013) observed transgression for reproductive and quality traits among recombinant inbred lines (RILs) derived from an interspecific cross between *G*. *hirsutum* and *G*. *barbadense*. Similarly, Roy *et al*. (2018) suggested the use of multiple crosses between varieties of *G*. *hirsutum* and *G*. *barbadense* for improving yield and its components.

LS line CNH 19-1 exhibited a significantly higher lint index (LI) value of 9.9 followed by GOT lines CNH 41-31 (8.8), CNH 41-94 (8.6) and CNH 33-94 (8.5) when compared to parental varieties Suraj and NH 615 which had LI values of 4.8 and 4.1, respectively. For seed index, LS line CNH 19-5 showed the highest value of 12.9 followed by GOT lines CNH 45-31 (12.7) and CNH 50-31 (12.5). Isong *et al*. (2019) suggested the development of a broad genetic base and more combinations for achieving better quality traits in *G*. *hirsutum* and *G*. *barbadense* crosses. Shi *et al*. (2020) also reported abundant genetic variation in the introgression lines of *Gossypium hirsutum* × *G*. *barbadense* produced by advanced backcrossing and continuous self-crossing.

Pearson's correlation coefficients among different yield components and fibre quality traits are presented in **Table 2**. Boll weight was correlated with seed index (0.51), lint index (0.34), micronaire (0.36) and seed cotton yield (0.47). The data suggest that selection for higher boll weight is accompanied by higher seed weight, higher lint index, higher micronaire and higher seed cotton yield. Height, boll number and boll weight were positively correlated with seed cotton yield with a correlation coefficient of 0.67, 0.34 and 0.47, respectively. The results indicate that these yield components are major contributors to the total variation of seed cotton yield. Ginning per cent was positively correlated with lint index (0.68) and negatively with strength (-0.38) indicating that with a higher ginning percentage there is an increase in lint index and lower fibre strength. Zeng *et al*. (2007) reported a significant negative correlation between lint percentage with fibre strength and lengths.

Seed index was positively correlated with lint index (0.70), length (0.38), micronaire ((0.05), strength (0.03) and seed cotton yield (0.02). Lint index was positively correlated with length (0.12) and had a negative or low correlation

Table 2. Pearson's correlation coefficients between fibre yield components and fibre quality traits

	BN	BWT	GOT	SI	LI	UHML	MC	ST	SCY
HT	0.193	0.607*	0.161	0.355*	0.275	0.107	0.180	-0.051	0.667*
BN		-0.195	-0.388*	-0.281	-0.316	0.319*	-0.068	0.306	0.343*
BWT			0.165	0.513*	0.344*	-0.108	0.361*	-0.308	0.466*
GOT				0.256	0.684*	-0.108	-0.306	-0.376*	-0.025
SI					0.696*	0.384*	0.046	0.031	0.023
LI						0.125	-0.158	-0.250	-0.066
UHML							-0.563*	0.411*	-0.037
MIC								-0.250	0.201
ST									-0.064

PH = Plant height , BN = Boll number per plant; BW = Boll weight ; GOT = Ginning outturn ; SI = Seed index; LI = Lint index; UHML = Upper half mean length ; MC = Micronaire; FS = Fiber strength; SCY = Seed cotton yield

* Significant at the 0.05 probability level

with micronaire (-0.16), strength (-0.25) and seed cotton yield (-0.07). Micronaire and strength were negatively correlated (-0.25). Among the fibre quality traits, fibre length and strength were highly and positively correlated (0.41) suggesting a strong possibility of selections for simultaneous improvement of fibre length and strength. Fibre length (-0.04) and fibre strength (-0.06) had a lesser negative association with seed cotton yield indicating breaking of strong negative correlation between yield and quality (either length or strength) in interspecific lines between *G. hirsutum* and *G. barbadense*. Percy *et al*. (2006) reported that fibre strength and 2.5% span length were favourably correlated in a recombinant inbred population.

The favourable correlations among length and strength provide evidence that future breeding efforts based on introgression between *G. hirsutum* and *G. barbadense* could result in the simultaneous improvement of length and strength. There were lesser negative non-significant associations between fibre yield and quality traits in the introgressed lines. This signifies the challenge in identifying introgressed lines with the desired combination of yield and quality. The results also indicate that backcross inbred lines are a useful genetic resource for genetic improvement of yield and fibre quality in upland cotton.

A significant genotypic variation was identified for seed cotton yield, yield components and fibre properties in introgressed lines. Lines *viz*., CNH 44-31, CNH 47-31, CNH 19-4, CNH 19-5 and CNH 42-6 were identified for a desirable combination of yield, its components and fibre quality. Lines viz., CNH 31-90, CNH 33-94 and CNH 48-4 had a combination of fibre quality and high ginning percentage. The results indicate that backcross inbred lines are a useful genetic resource for genetic improvement of yield and fibre quality in upland cotton.

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