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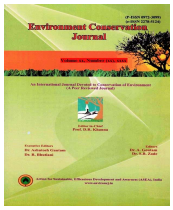

Morphological, yield and quality performance of introgression trispecies derivatives of cotton (*G. hirsutum* L. x *G. barbadense* L.) x *G. arboreum* L.)

G. R. Lahane ✉
Cotton Research Station, Nanded, Vasantrao Naik Marathwada Agricultural University, Parbhani, Maharashtra, India.
Khizer Baig
Cotton Research Station, Nanded, Vasantrao Naik Marathwada Agricultural University, Parbhani, Maharashtra, India.
Arun Gaikwad
Cotton Research Station, Nanded, Vasantrao Naik Marathwada Agricultural University, Parbhani, Maharashtra, India.
Adeel Syed
Cotton Research Station, Nanded, Vasantrao Naik Marathwada Agricultural University, Parbhani, Maharashtra, India.

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ABSTRACT

The experiment was carried out in CRS, Nanded, Vasantrao Naik Marathwada Agricultural University, to evaluate the effect of chromosomal ploidy level on morphological, yield and quality parameters of introgressed trispecies derivatives of cotton. Fifty introgressed trispecies derivatives of the cotton genotype obtained in the BC_1F_{21} generation of a trispecies cross of [(*G. hirsutum x G. barbadanse*) x *G. arboreum*] were used to determine the chromosomal behaviour, yield, morphology and fibre quality traits. During meiosis, variation in chromosome number ranging from 47 to 54.5 was observed against the normal chromosomal behaviour of *G. arboreum* (2n == 26) and *G. hirsutum* (2n=4x=52). Yield and morphologically, these derivatives increased significantly over the check varieties, while fibre quality traits, viz., upper half mean length (UHML) and uniformity index, were found to be inferior than the check hybrid DCH-32, however, it was followed by other checks, viz., NH-615, DHY-286 and PA-183. The fibre strength was found to be superior over all the checks. These results indicate that these developed lines had introgression character from species viz., *hirsutum, arboreum* and *barbadense.*

Introduction

Cotton is an important fibre crop of global importance. India has a pride place in the global cotton market, it has the distinction of having the largest cotton area of 12 million hectares, and production of 32.8 million bales (1 bale= 170 kg lint) (Anonymous, 2018). The cultivated amphidiploid species, *G. hirsutum* L. and *G. barbadense* L. cross readily, and the F_1 hybrid shows regular bivalent pairing and is apparently fully fertile. F_2 progenies show considerable depression in vigor, and the net effect of inbreeding is the establishment of types practically indistinguishable from the parent species. All intermediate types are at a great selective disadvantage and fail to establish themselves. A similar situation is found in the hybrid progenies of the Asiatic cultivated diploid species, *G. arboreum* L. and *G. herbaceum* L. Harland's interpretation of these phenomena is that the species differences are mainly attributable to differences in "genetic architecture." The regular bivalent pairing and full fertility of the F_1 hybrid has usually been considered to support Harland's hypothesis (Dobzhansky, 1941; Silow, 1941; Mather 1943). Almost all the species studied have been grouped into seven diploid genomes (A, B, C, D, E, F, and G) and one tetraploid genome (AD). The A subgenome of cultivated diploid cotton has been shown to be homologous to the A genome of the teraploid cotton and the D subgenome of wild

Corresponding author E-mail: ganeshlahane904@gmail.com
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American species to those of the D subgenome of tetraploid cotton. The hybrids between the A and D genomes are of great significance, as they will bear out the amphidiploid origin of tetraploid cotton. Such hybrids, when doubled, may prove potential in expanding the pool of new germplasm for the future improvement of tetraploid cotton.

Material and Methods

The material for the present investigation includes interspecific trispecies derivatives of the BC_1F_{21} generation, viz., IS-244/4/1 and IS-181/7/1, available at the cotton research station, Nanded. These introgressed lines were developed from a cross of DCH-32 (into a specific F_1 hybrid of *G. hirsutum x G. barbadense*) with the strain NA 80/679 of *G. arboreum* (race *bengalense*). To match the ploidy level, tetraploidy was induced by treating *G. arboreum* with colchicine. The trispecies F_1 obtained [(*G. hirsutum x G. barbadense*) x 4n *G. arboreum*)] was pollinated on the stigma of C1 plants to obtain BC_1F_{21} seeds. Plants showing distinct morphological characteristics in the BC_1F_{21} generation were isolated and advanced up to the BC_1F_{21} generation. Although the present material is presently in the BC_1F_{21} generation, segregation is still observed for morphological and economic traits. The seeds of these lines were obtained from Cotton Research Station, Nanded, VNMKV, Parbhani (Table 1). The trispecies derivatives of the BC_1F_{21} generation along with standard checks represented by two row plots of 10 plants, placed at 60 x 30 cm with two replications. All the agronomical practices and plant protection measures followed as required to raise a good crop of cotton. Observations of yield, morphological and fiber quality traits were recorded. A standard statistical procedure was followed for analyse the data according to Panse and Sukhatme (1967).

Table 1: List of the interspecific trispecies derivatives BC_1F_{21} generation

Sr. No.	Name of the derivatives	Sr. No.	Name of the derivatives
1	IS-1-1	26	IS-32-15
2	IS-1-2	27	IS-33-1
3	IS-1-3	28	IS-33-4
4	IS-1-4	29	IS-33-5
5	IS-1-5	30	IS-34-5
6	IS-1-6	31	IS-34-9
7	IS-2-1	32	IS-35-11
8	IS-2-2	33	IS-36-12
9	IS-2-4	34	IS-39-4
10	IS-2-5	35	IS-43-2
11	IS-2-6	36	IS-43-3
12	IS-2-7	37	IS-43-5
13	IS-2-8	38	IS-43-6
14	IS-3-1	39	IS-43-7
15	IS-3-2	40	IS-43-9
16	IS-3-5	41	IS-43-10
17	IS-8-1	42	IS-43-12
18	IS-11-5	43	IS-43-13
19	IS-16-8	44	IS-43-14
20	IS-17-1	45	IS-43-15
21	IS-28-1	46	IS-44-1
22	IS-31-6	47	IS-44-3
23	IS-31-7	48	IS-44-7
24	IS-32-9	49	IS-43-4
25	IS-32-12	50	IS-43-8
Standard Checks	1) PA 183 (*G. arboreum* 2n=26) 2) DHY 286 (*G. hirsutum* 2n= 52) 3) NH 615 (*G. hirsutum* 2n= 52) 4) DCH 32 (*G. hirsutum* x *G. barbadense* interspecific hybrid 2n=52)		

Yield contributing parameters

Number of bolls per plant

Number of bolls per plant from which seed cotton was picked during each picking was recorded and mean value for number of bolls per plant was calculated.

Boll weight (g)

At the time of second picking, seed cotton from ten well opened bolls, from each genotype was collected and weighed. Mean value was calculated and recorded.

Seed cotton yield per plant (g)

The seed cotton obtained from five randomly selected plants was weighed separately and mean seed cotton yield per plant was recorded.

No. of seeds per boll

Number of seeds per boll were isolated from cotton lint and recorded.

Ginning percentage (%)

Ginning percentage is the ratio of weight of lint to that of seed cotton expressed in percentage. The seed cotton was ginned by hand gin and weight of lint was recorded on the balance with 0.1 per cent sensitivity and ginning percentage was calculated by using following formula.

$$\text{Ginning percentage (\%)} = \frac{\text{Weight of lint (g)}}{\text{Weight of seed cotton (g)}} \times 100$$

Morphological studies

Plant height

The height of plant in cm was recorded at maturity from the base of the main stem at ground level to the tip of the fully opened leaf of main stem.

Leaf studies

Leaf characters like number of lobes, total leaf length at middle lobe and breadth as well as leaf angle were recorded.

Calyx tube

The calyx tube length was measured from the base of pedicel in centimeter.

Corolla

The colour of petals was recorded and size recorded in cm.

Staminal column

The length of staminal column was measured in cm.

Ovary

Diameter of the ovary was recorded in cm.

Bractioles

Length and breadth of bracteole were recorded in cm.

No. of locule

Number of locule / ovary.

Fibre properties

Upper half mean length (UHML) (mm)

(UHML = 0.98 x 2.5 % Staple Length + 0.1827)

Uniformity index (%)

(UI %= -0.184 x Uniformity ratio % + 91.17)

Micronaire value (µg / inch)

It is the average weight per unit length of fiber. It is used in determining the fiber fineness, linear density of fiber is expressed in micrograms per inch.

Fibre strength (g / tex)

It is the force required to break bundle of fiber of unit linear density. The fiber strength was determined by using HVI and expressed in grams per tex.

Results and Discussion

Yield contributing characters

The observations of seed cotton yield per plant, average boll weight, seeds per boll, number of bolls per plant and ginning percentage are presented in Table 2.

Seed cotton yield per plant (g)

The highest seed cotton yield per plant was recorded for derivatives IS-43-9 (48.70 g), followed by derivatives IS-1-4, IS-1-6, IS-36-12 and IS-44-3 (48.65 g, 47.75 g, 47.65 g and 46.93 g), respectively. The check varieties DHY-286, DCH-32, PA-183 and NH-615 recorded seed cotton yields of 34.90 g, 42.80 g, 43.70 g and 38.87 g respectively.

Average boll weight (g)

The highest boll weight was recorded in derivatives IS-43-7 (4.40 g), which showed a significant increase over checks varieties DHY-286, DCH-32, PA-183 and NH-615 (2.91 g, 2.78 g, 3.04 g and 3.30 g, respectively), followed by three derivatives IS-1-6, IS-2-5 and IS-2-8 (3.97 g, 4.00 g and 4.31 g, respectively).

Seeds per boll

The highest number of seeds per boll was recorded in check, NH-615 (21.06), followed by PA-183, DHY-286 and DCH-32 (21.04, 20.95 and 20.76, respectively).

Number of bolls per plant

The highest number of bolls per plant was recorded in derivatives IS-36-12 (28.33) which was significantly higher than that in the check varieties DHY-286 (12.01), DCH-32 (15.41), PA-183 (14.43) and NH-615 (11.83).

Ginning (%)

The highest ginning was recorded in derivatives IS-35-11 (39.93 %), whereas a lower ginning outturn was recorded by derivatives IS-1-3 (30.91 %), IS-1-4 (31.18 %), IS-1-5 (29.54 %), IS-2-6 (16.85 %), IS-31-6 (23.35 %), IS-33-5 (31.28 %), IS-34-9 (31.76 %), IS-43-5 (29.52 %), IS-43-7 (31.72 %), IS-43-10 (31.58 %), IS-43-4 (29.04 %) and check variety DHY-286 (25.52 %).Introgressed trispecies derivative IS-43-9 recorded the highest seed cotton yield per plant (48.70 g), which is nullisomic and has an average chromosome number of (2n=51), followed by other derivatives, viz., IS-1-4 (48.65 g), IS-1-6 (47.75 g), IS-36-12 (47.65 g) and IS-44-3 (46.93 g). However, derivative IS-32-15 (9.88 g) recorded the lowest yield per plant. Average boll weight was recorded in derivative IS-43-7 (4.40 g), which was significantly superior to all the checks viz., DHY-286 (2.91g), DCH-32 (2.78 g), PA-183 (3.04 g) and NH-615 (3.30 g), followed by three derivatives viz.,

Table 2: Mean performance for different traits studied in interspecific trispecies derivatives in BC_1F_{21} generation

SN	Character	IS-1-1	IS-1-2	IS-1-3	IS-1-4	IS-1-5	IS-1-6	IS-2-1	IS-2-2	IS-2-4	IS-2-5	IS-2-6	IS-2-7	IS-2-8	IS-3-1	IS-3-2	IS-3-5
1	Total chromosome number	42.5	54.5	49	52.5	42.5	47.5	42	36	41.25	50	44.5	47.5	47	46	46	42
2	Seed cotton yield/plant (gm)	19.21	21.05	23.33	48.65	41.75	47.75	12.76	10.73	18.25	24.95	25.65	18.54	14.78	25.67	25.51	26.8
3	Average boll weight ((gm)	2.95	3.25	3.71	3.14	2.27	3.97	2.89	3.16	3.48	4	3.94	3.51	4.31	3.63	3.48	3.64
4	Number of seeds/ boll	14.02	13.41	12.56	19.85	14.48	18.81	13.6	14.43	13.42	14.42	12.28	13.25	14.63	14.24	13.47	14.51
5	Number of bolls/ plant	6.51	6.49	6.31	15.51	18.38	12.05	4.42	3.41	5.24	6.25	6.53	5.33	3.44	7.08	7.34	7.36
6	Ginning percentage (%)	37.41	37.44	30.91	31.18	29.54	35.46	35.1	34.71	35.46	36	16.85	32.12	37.21	35.25	35.83	34.2
7	Plant height (cm)	84.5	82.67	84.75	92.11	112	116.04	95.1	77.05	90	104.26	79.21	92.25	88.95	147.76	102.34	118.26
8	Number of leaf lobes	3.43	3.68	3.79	4.62	4.5	5.41	4.85	3.76	3.84	4.46	4.61	4.5	3.25	5	4.84	4.36
9	Length of middle lobe (cm)	4.73	5.82	6.83	7.04	6.61	6.88	6.19	5.89	6.24	6.34	7.75	6.51	7.31	8.31	6.91	7.5
10	Breadth of middle lobe (cm)	2.39	3.51	3.3	3.56	2.05	3.46	3.1	3.16	2.31	3.56	4.75	4.01	4.03	3.71	3.76	3.76
11	Leaves angle 0	67.75	64.83	62.5	63.66	63.5	51.5	60.5	56.5	63.5	76.45	58.5	55.05	55.65	53.5	60.65	46.5
12	Leaf thickness (mm)	0.46	0.45	0.48	0.46	0.46	0.48	0.35	0.44	0.46	0.48	0.47	0.46	0.45	0.47	0.42	0.47
13	Calyx tube (cm)	0.45	0.61	0.68	0.73	0.59	0.64	0.56	0.45	0.55	0.61	0.54	0.46	0.65	0.66	0.78	0.74
14	Corolla length (cm)	2.33	2.14	2.22	2.29	2.15	2.15	2.05	1.69	2.44	2.45	2.54	2.25	2.17	2.15	2.65	2.74
15	Corolla breadth (cm)	1.28	1.62	1.54	1.27	1.13	1.24	1.06	1.38	1.54	1.66	1.34	1.47	0.76	1.22	1.45	2.32
16	Staminal column (cm)	0.73	0.77	0.48	0.77	1.06	1.1	0.74	0.63	0.94	1.01	1.02	0.67	0.71	1.17	1.66	1.27
17	Ovary diameter (cm)	2.21	1.82	2.15	1.95	1.87	1.97	1.84	1.68	1.56	1.91	1.91	1.82	1.76	1.67	2.14	1.78
18	Bractiole length (cm)	1.96	1.67	1.72	1.41	1.26	1.51	1.56	1.41	1.83	1.52	1.74	1.54	1.77	1.65	1.65	1.96
19	Bractiole breadth (cm)	0.93	1.38	1.6	1.49	1.35	1.35	1.52	1.32	1.84	1.89	1.53	1.51	1.27	1.45	1.53	1.47
20	Number of locules	4	3.33	3.66	4	3.5	3.5	3	4	4	4	4	3.5	4	3.5	4	4
21	Upper half mean length (mm)	28.63	29.01	26.18	25.74	28.75	29.37	29.06	27.7	28.79	28.69	29.15	29.8	25.18	27.29	27.43	27.74
22	Uniformity index (%)	82.55	83.2	80.25	84.7	83.2	84.55	87.45	86.25	85.65	80.9	83.2	82.05	84.7	84.5	85.35	84.45
23	Micronaire value (mg / inch)	3.42	3.42	3.57	4.28	3.87	3.93	3.34	3.83	3.79	3.82	3.69	4.27	4.27	3.79	3.69	4.27
24	Fibre strength (g / tex)	25.8	28.45	27.55	29.25	26.6	28.7	28.75	30.55	29.65	26.45	25.3	28.15	29	26.85	27.9	28.05

Table 2 a: Mean performance for different traits studied in interspecific trispecies derivatives in BC_1F_{21} generation

SN	Character	IS-8-1	IS-11-5	IS-16-8	IS-17-1	IS-28-1	IS-31-6	IS-31-7	IS-32-9	IS-32-12	IS-32-15	IS-33-1	IS-33-4	IS-33-5	IS-34-5	IS-34-9	IS-35-11
1	Total chromosome number	35	36.5	45.5	47	43.5	38	34	42.5	44.5	40	49	49	40.5	35	38.5	32.5
2	Seed cotton yield/plant (gm)	18.68	35.26	29.24	38.15	20.96	26.4	28.65	11.44	16.74	9.88	25.94	10.24	22.28	38.29	20.43	30.14
3	Average boll weight ((gm)	1.11	2.34	3.19	2.76	2.3	3.92	2.78	2.27	1.88	2.74	3.38	2.56	2.81	3.07	2.56	3.39
4	Number of seeds/ boll	14.35	14.52	14.57	13.2	13.3	14.28	13.37	14.88	13.15	14.67	14.37	13.47	14.55	13.25	14.36	13.48
5	Number of bolls/ plant	17.13	15.28	9.16	13.85	9.13	6.73	10.34	5.02	9.06	3.64	7.67	4	7.93	12.46	8.09	8.89
6	Ginning percentage (%)	36.3	38.42	38.23	39.24	35.57	23.35	35.09	34.71	35.11	39.17	32.96	34.51	31.28	38.5	31.76	39.93
7	Plant height (cm)	104.67	150.14	156.5	130.5	127.5	125.63	119.75	114.76	102.28	103.5	136	131.5	132.63	108	95.05	103.84
8	Number of leaf lobes	3.36	4.24	3.76	4.5	4.61	4.73	3.83	4.6	4.43	4.5	4.65	3.85	4.55	3.81	2.65	4.25
9	Length of middle lobe (cm)	6.81	8.36	8.43	6.64	8.51	7.5	8.25	7.2	6.41	8.01	6.22	6.64	7.31	8.46	7.26	6.43
10	Breadth of middle lobe (cm)	3.54	3.54	3.55	3.95	3.45	3.56	3.85	3.1	3.65	4	3.35	3.45	3.59	4.2	3.55	3.1
11	Leaves angle 0	56.5	59.5	47.5	61	67.5	62	57.5	57.5	59.5	74.5	77.5	56.5	60.8	71.85	61	69.7
12	Leaf thickness (mm)	0.49	0.48	0.45	0.45	0.45	0.45	0.44	0.44	0.45	0.43	0.43	0.46	0.5	0.51	0.48	0.45
13	Calyx tube (cm)	0.75	0.86	1.04	0.85	0.95	0.96	0.87	0.87	0.38	1.21	1.04	0.81	0.93	0.67	0.77	0.95
14	Corolla length (cm)	2.94	2.45	3.08	3.15	2.75	2.93	3.25	2.88	1.65	2.44	2.85	2.85	1.98	2.74	2.69	3.12
15	Corolla breadth (cm)	1.67	1.17	1.92	1.91	1.45	1.83	1.89	1.7	1.06	2.07	1.95	1.57	1.77	2.11	2.17	1.7
16	Staminal column (cm)	1.21	1.01	1.43	1.51	1.59	1.65	2.11	1.46	0.93	1.18	1.44	1.24	1.75	1.65	1.33	1.51
17	Ovary diameter (cm)	2.01	1.77	2.11	1.94	2.01	2.51	2.27	2.28	1.24	1.97	2.51	2.35	2.51	2.07	2.33	2.72
18	Bractiole length (cm)	2.03	1.39	2.03	1.8	1.83	2.03	2.27	1.85	1.44	1.94	2.04	1.86	2.05	3.53	2.02	2.71
19	Bractiole breadth (cm)	1.93	1.44	1.72	1.77	1.53	1.85	2.23	2.4	2.06	1.93	2.05	1.96	2.17	2.32	1.99	1.64
20	Number of locules	3.5	3.5	3.5	4	3.66	4	3.5	4	3.5	3.5	4.17	4	3.5	4	3.5	4
21	Upper half mean length (mm)	27.32	29.14	28.45	28.36	28.2	29.15	27.11	27.37	29.45	25.28	29.8	28.38	29.61	29.74	29.95	29.51
22	Uniformity index (%)	84.4	83.65	84.65	81.9	83.65	84.6	81.4	83.45	84.95	82.5	86.35	85.65	83.95	81	84.75	82.05
23	Micronaire value (mg / inch)	3.67	3.44	3.59	3.53	3.53	3.35	4.37	4.36	3.41	3.59	3.89	3.9	3.35	3.87	3.75	3.97
24	Fibre strength (g / tex)	27.9	29.15	28.1	26.4	26.8	28.6	26.4	28.05	29.25	30.7	28.65	29.35	30.05	26.25	27.75	27.6

Table 2 b: Mean performance for different traits studied in interspecific trispecies derivatives in BC_1F_{21} generation

SN	Character	IS-36-12	IS-39-4	IS-43-2	IS-43-3	IS-43-5	IS-43-6	IS-43-7	IS-43-9	IS-43-10	IS-43-12	IS-43-13	IS-43-14	IS-43-15	IS-44-1	IS-44-3	IS-44-7
1	Total chromosome number	44	44.5	44.5	39	42	38.5	32	51	42	32.5	41	54	54	45.5	45.5	42
2	Seed cotton yield/plant (gm)	47.65	12.07	21.68	25.68	33.15	44.62	28.8	48.7	25.2	15.03	38.05	24.88	31.67	17.66	46.93	22.02
3	Average boll weight ((gm)	1.71	2.23	1.98	3.36	2.41	3.49	4.4	3.46	3.16	3.13	2.8	2.85	3.62	3.07	2.93	2.92
4	Number of seeds/ boll	14.37	14.56	13.88	13.38	14.39	17.7	14.64	19.89	13.42	14.17	13.59	14.27	13.07	14.23	17.73	14.62
5	Number of bolls/ plant	28.33	5.49	11.11	7.67	13.8	12.8	6.58	14.12	8.02	4.8	13.66	8.81	8.79	5.8	16.18	7.55
6	Ginning percentage (%)	35.75	34.7	32.62	36.3	29.52	38.7	31.72	37.09	31.58	37.93	38.39	38.26	34.6	35.98	38.51	38.76
7	Plant height (cm)	128.76	60.16	63	107	102.34	96	107	109	100.5	105.83	109.34	105.67	101.5	107.67	103.5	108.16
8	Number of leaf lobes	3.77	3.45	3.55	4.85	3.5	3.45	4.5	3.85	4.51	4.27	4.61	4.41	4	3.5	3.36	4.41
9	Length of middle lobe (cm)	6.9	7.14	7.01	7.2	5.9	6.26	5.77	7.75	7.33	7.5	7.45	7.74	8	8.5	7.83	9.55
10	Breadth of middle lobe (cm)	3.25	3.76	3.55	3.15	3	3.3	3.39	3.55	3.55	3	3.76	3.65	3.85	3.55	3.55	4.21
11	Leaves angle 0	57.95	58.75	71.75	52.5	80.5	69.5	74.5	57.5	61	65.5	55.25	49.5	51.5	57.16	50.5	55.5
12	Leaf thickness (mm)	0.47	0.45	0.46	0.43	0.44	0.45	0.47	0.47	0.45	0.47	0.48	0.48	0.47	0.49	0.41	0.5
13	Calyx tube (cm)	1.01	0.99	0.67	0.82	0.87	0.8	0.74	1.03	0.78	0.62	0.71	0.97	0.87	0.91	0.95	1.04
14	Corolla length (cm)	2.96	2.12	2.26	2.56	2.43	3.08	2.27	2.94	2.32	1.95	2.35	3.12	2.84	2.58	2.54	3.07
15	Corolla breadth (cm)	1.67	1.62	1.14	1.72	1.76	1.93	1.23	1.54	3.87	1.43	1.57	1.93	1.91	1.31	1.47	1.64
16	Staminal column (cm)	1.61	1.41	0.96	1.14	0.94	1.57	0.86	3.11	1.08	0.93	1.31	1.12	1.17	0.97	0.88	1.64
17	Ovary diameter (cm)	2.26	2.17	2.01	2.02	2	2.17	1.91	3.11	2.25	2.01	2.01	2.38	2	1.85	2.21	2.02
18	Bractiole length (cm)	2.01	2.64	1.73	1.78	1.42	1.59	2.06	2.11	1.74	1.07	1.66	2.22	1.94	1.74	2.14	1.64
19	Bractiole breadth (cm)	1.77	1.81	2	1.92	1.77	2.17	1.93	2.11	1.75	1.03	1.67	2.24	1.97	1.74	2.13	1.64
20	Number of locules	3.5	4.17	3	3.5	3.83	3	4	4	3.5	3.5	3.33	3.5	3.5	3.66	3.33	4
21	Upper half mean length (mm)	26.65	27.78	27.86	28.85	27.2	28.28	29.58	28.87	27.85	29.75	26.58	28.68	26.46	27.51	26.35	27.93
22	Uniformity index (%)	83.25	84.45	82.35	83.95	85.25	83.25	84.95	81.75	84.05	82.95	81.45	83.3	81.75	81.3	81.75	83.75
23	Micronaire value (mg / inch)	3.75	3.75	3.44	3.59	3.47	3.57	3.45	3.34	3.73	3.61	3.28	3.87	3.48	3.47	3.86	3.48
24	Fibre strength (g / tex)	29.7	26.8	26.25	29.3	29.5	26.55	28.45	25.5	27.65	28.65	29.65	26.6	27.5	29.45	28.5	28.55

Table 2 c: Mean performance for different traits studied in interspecific trispecies derivatives in BC_1F_{21} generation

SN	Character	IS-43-4	IS-43-8	DHY-286	DCH-32	PA-183	NH-615	SE±	CD @ 5 %	CV
1	Total chromosome number	32.5	38.5	52	52	26	52			
2	Seed cotton yield/plant (gm)	26.06	15.97	34.9	42.8	43.7	38.87	0.97	2.76	5.05
3	Average boll weight ((gm)	2.67	2.5	2.91	2.78	3.04	3.3	0.16	0.45	7.46
4	Number of seeds/ boll	13.55	14.53	20.95	20.76	21.04	21.06	0.14	0.39	1.3
5	Number of bolls/ plant	9.78	6.4	12.01	15.41	14.43	11.83	0.98	2.79	14.65
6	Ginning percentage (%)	29.04	37.93	25.2	36.94	34.06	39.21	2.75	7.81	11.24
7	Plant height (cm)	105.67	89.25	105.85	125.15	219.15	133.9	3.14	8.1	4.07
8	Number of leaf lobes	4	4.5	4.64	5	5.26	3.36	0.2	0.56	6.69
9	Length of middle lobe (cm)	7.5	7.16	7.95	7.5	7.83	8.55	0.34	0.95	6.58
10	Breadth of middle lobe (cm)	3.55	3.15	4.65	3.25	1.2	4.35	0.05	0.15	2.11
11	Leaves angle 0	59.5	48.45	61.5	54.5	65.5	60.65	0.6	1.69	1.39
12	Leaf thickness (mm)	0.47	0.44	0.5	0.44	0.5	0.45	0	0.01	0.82
13	Calyx tube (cm)	0.78	0.87	0.87	0.81	0.61	1.06	0.02	0.06	4.02
14	Corolla length (cm)	2.3	2.22	3.08	3.15	2.98	2.93	0.05	0.13	2.61
15	Corolla breadth (cm)	1.67	1.64	1.76	1.62	1.52	1.85	0.02	0.05	1.55
16	Staminal column (cm)	1.67	1.63	1.72	1.59	1.52	1.62	0.07	0.19	7.56
17	Ovary diameter (cm)	1.92	2.01	2.08	2.21	1.79	2.04	0.03	0.07	1.76
18	Bractiole length (cm)	2.01	1.83	2.97	3.13	2.16	2.47	0.08	0.22	5.66
19	Bractiole breadth (cm)	2.01	1.81	2.97	3.11	2.12	1.53	0.01	0.04	1.17
20	Number of locules	3.5	4	4	3.66	4	4	0.19	0.55	7.44
21	Upper half mean length (mm)	28.71	26.65	26.25	32.05	25.05	26.6	0.43	1.23	2.18
22	Uniformity index (%)	83.45	84.55	83.85	87.3	81.5	84.4	0.47	1.33	0.79
23	Micronaire value (mg / inch)	3.76	3.42	3.86	2.7	4.56	3.31	0.04	0.13	1.72
24	Fibre strength (g / tex)	26.65	28.4	26.15	29.1	26.45	25.15	0.69		3.49

IS-1-6 (3.97 g), IS-2-5 (4.00 g) and IS-2-8 (4.31 g) indicating that the traits viz., yield per plant and average boll weight considerably improved over parents and checks. The numbers of bolls per plant and ginning percentage exhibited the highest heterosis over the controls. The results obtained are in accordance with earlier studies of Deshpande *et al.* (1991), Meshram and Tayyab (1991and 1994), Quian Siying (1996), Ding *et al.* (1999), Mehetre *et al.* (2003 a), Mehetre *et al.* (2003) and Kamdi *et al.* (2006). Saitwal *et al.* (2003) reported a very low possibility of improving traits viz., seeds per boll, which may be due to post fertilization barriers, lower pollen fertility and the development of bolls and seeds due to unequal pairing and irregular separation of chromosomes.

Morphological observations

Observations of fifteen following morphological traits in introgressed trispecies derivatives compared with two *G. hirsutum* varietal checks, viz., DHY-286 and NH-615, one interspecific hybrid check DCH-32 (*G. hirsutum* x *G. barbadense*) and one *arboreum* check PA-183.

Plant height (cm)

Plant height in introgressed trispecies derivative derivatives was found to be significantly more or less than that in the controls. The highest plant height was recorded in *G. arboreum* check variety PA-183 (219.15 cm), whereas the lowest plant height was recorded in strain IS-39-4 (60.16 cm).

No. of leaf lobes

Palmate types of leaf lobes were recorded in all the derivatives except IS-1-5 and the check variety, PA-183, which had a semi okra or digitate leaf shape. The highest no. of leaf lobes (5.41) was recorded in IS-1-6 and was found at par with derivatives viz., IS-2-1, IS-43-3 and the check hybrid DCH-32 and variety PA-183.

Length of middle lobe (cm)

The highest length of the middle lobe (9.55 cm) was recorded in derivatives IS-44-7. Trispecies recorded significantly more middle lobe length than all four check varieties.

Breadth of the middle lobe (cm)

The highest breadth of the middle lobe (4.75 cm) was recorded in derivatives IS-2-6 and was found at par with the check variety DHY-286. Trispecies derivatives recorded significantly higher middle lobe length compared to check varieties.

Leaf Angle

The highest leaf angle (80.50^0) was recorded in derivatives IS-43-5. Leaf angles of, 65.50^0, 61.50^0, 60.65^0 and 54.50^0 were recorded in *arboreum* check PA-183 and the *hirsutum* check varieties DHY-286, NH-615, and DCH-32, respectively. This indicates that the leaf angle in trispecies derivatives was significantly higher than that in check varieties.

Leaf thickness (mm)

The highest leaf thickness (0.51 mm) was recorded in derivatives IS-34-5 and was found at par with derivatives viz., IS-33-5, IS-44-7, check DHY-286 and PA-183. Nine derivatives, viz., IS-1-3 (0.48 mm), IS-1-6 (0.48 mm), IS-2-5 (0.48 mm), IS-8-1 (0.49 mm), IS-11-5 (0.48 mm), IS-34-9 (0.48 mm), IS-43-13 (0.48 mm), IS-43-14 (0.48 mm) and IS-44-1 (0.49 mm), significantly higher leaf thickness than check, DCH-32 and NH-615.

Flower colour

Mostly, petal colour in trispecies derivatives was observed as (white, yellow and creamy), however, six varieties and two checks recorded creamy flower colour, i.e., IS-1-1, IS-1-2, IS-1-3, IS-1-4, IS-1-5, IS-1-6, along with check varieties DHY-286 and DCH-32, however, the remaining derivatives recorded yellow color. Dark petal spot was also recorded in strain IS-1-5, which was similar to the interspecific hybrid DCH-32.

Calyx tube length (cm)

The highest calyx tube length (1.21 cm) was recorded in derivatives IS-32-15, whereas check varieties DHY-286, DCH-32, PA-183 and NH-615 recorded calyx tube lengths of 0.87 cm, 0.81 cm, 0.61 cm and 1.06 cm, respectively. These results indicated that the length of the calyx tube in trispecies derivatives was significantly higher than that in check varieties.

Corolla length (cm)

The derivatives IS-31-7 (3.25 cm) showed significantly higher corolla length than the controls, PA-183 and NH-615, followed by derivatives IS-17-1 (3.15 cm), IS-35-11 (3.12 cm), and IS-43-14 (3.12 cm) and hybrid, DCH-32 (3.15 cm).

Corolla breadth (cm)

The highest corolla breadth was recorded in derivatives IS-43-10 (3.87 cm). Trispecies derivatives, viz., IS-3-5, IS-34-5 and IS-34-9, recorded 2.32 cm, 2.11 cm and 2.17 cm, respectively. All four check varieties, viz., DHY-286, DCH-32, PA-183 and NH-615, recorded

corolla breadths below 2 cm i.e. 1.76 cm, 1.62 cm, 1.52 cm and 1.85 cm, respectively. This indicates that corolla breadth in trispecies derivatives was significantly higher than that in check varieties.

Length of staminal column (cm)

The longest length of the staminal column was recorded in derivatives IS-43-9 (3.11 cm). All four check varieties, viz., DHY-286, DCH-32, PA-183 and NH-615, recorded 1.72 cm, 1.59 cm, 1.52 cm and 1.62 cm stamina column lengths, respectively.

Ovary diameter (cm)

The highest ovary diameter (3.11 cm) was recorded in derivatives IS-43-9, which was found to be significantly higher than that in the check varieties DHY-286 (2.08 cm), DCH-32 (2.21 cm), PA-183 (1.79 cm) and NH-615 (2.04 cm).

Bracteole length (cm)

The highest bracteole length (3.53 cm) was recorded in derivatives IS-34-5, which was significantly higher than that in the check varieties DHY-286 (2.97 cm), DCH-32 (3.13 cm), PA-183 (2.16 cm) and NH-615 (2.47 cm).

Bracteole breadth (cm)

The highest bracteole breadth was recorded in the check variety, DCH-32 (3.11 cm), which was significantly higher than that in the other check varieties, viz., DHY-286 (2.97 cm), PA-183 (2.12 cm) and NH-615 (1.53 cm), and the rest of the trispecies derivatives.

Number of locules per plant

The highest number of locules per ovary was recorded in derivatives IS-33-1 and IS-39-4 (4.17), which was found at par with all derivatives except the derivatives IS-1-2, IS-1-5, IS-1-6, IS-2-1, IS-2-7, IS-3-1, IS-8-1, IS-11-5, IS-16-8, IS-31-7, IS-32-12, IS-32-15, IS-33-5, IS-34-9, IS-36-12, IS-43-2, IS-43-3, IS-43-6, IS-43-10, IS-43-12, IS-43-13, IS-43-14 IS-43-15, IS-44-3 and IS-43-4.

The highest plant height (cm) was recorded in the *G. arboreum* check variety, PA-183 (219.15 cm), whereas the plant height recorded in the introgressed trispecies derivatives was more or less equal to the *hirsutum* checks, viz., DHY-286, DCH-32 and NH-615. Palmate –type leaf shape was recorded in all derivatives and checks except derivatives IS-1-5 and the check variety, PA-183, which was recorded as semiokra or digitate leaf shape. The leaf morphology of the IS-1-5 derivative was similar to that of *G. arboreum* check, PA-183. The number of leaf lobes, length of the middle lobe, breadth of the middle lobe and leaf angle were recorded to be significantly highest over the *G. arboreum* check, PA-183 and *G. hirsutum* check varieties, viz., DHY-286 and NH-615, and the interspecific hybrid check, DCH-32 (*G. hirsutum x G. barbadnese*). The results of the present investigation are in agreement with those reported by Deshpande *et al.* (1991) and Meshram and Tayyab (1994). The highest leaf thickness was recorded in derivative IS-34-5 (0.51 mm), which was higher than *G. arboreum* check, PA-183 (0.50 mm) and DHY-286 (0.50 mm). Derivatives having leaf thickness values near or above check varieties also showed resistance against sucking pests, viz., aphids, jassids, thrips and whiteflies. These findings of leaf thickness studies are in agreement with the reports of Malik and Nandal (1986), Sharma and Agarwal (1983), Butter *et al.* (1989), Raza *et al.* (1999), Bashir *et al.* (2001), Muhammad *et al.* (2004), Sarvanan *et al.* (2005), Guljar *et al.* (2005), Arif (2006) and Vanitha *et al.* (2007). The floral character petal colour in trispecies derivatives was observed as white, yellow and cream, however, six strains, viz., IS-1-1, IS-1-2, IS-1-3, IS-1-4, IS-1-5 and IS-1-6, and two checks, viz., DHY-286 and DCH-32, recorded cream flower colour, however, the rest of the derivatives recorded yellow petal colour. Dark petal spot was recorded in strain IS-1-5, which was found to be similar to the interspecific hybrid DCH-32, while other floral characters, viz., calyx tube length, corolla length, corolla breadth, length of the staminal column, ovary diameter, bracteole length, bracteole breadth, and number of locules in trispecies derivatives, were found to be comparatively higher over checks with vigorous growth. The results are in agreement with earlier reports of Deodikar (1949), Thombre and Mehtre (1981), Deshpande *et al.* (1991), Meshram and Tayyab (1991), Saitwal *et al.* (2003), Sarvanan *et al*. (2005), Kamdi *et al.* (2006) and Ramamoorthy (2006).

Fibre properties

The observations of seed cotton upper half mean length (UHML), uniformity index, Micronaire value and fiber strength are presented in Table 2.

Upper half mean length (UHML) (mm)

The highest upper half mean length (UHML) was recorded in check DCH-32 (32.05 mm), followed

by derivatives IS-1-2 (29.01 mm), IS-1-6 (29.37 mm), IS-2-1 (29.06 mm), IS-2-6 (29.15 mm), IS-2-7 (29.80 mm), IS-11-5 (29.14 mm), IS-31-6 (29.15 mm), IS-32-12 (29.45 mm), IS-33-1 (29.80 mm), IS-33-5 (29.61 mm), IS-34-5 (29.74 mm), IS-34-9 (29.95 mm), IS-35-11 (29.51 mm), IS-43-7 (29.58 mm) and IS-43-12 (29.75 mm), which recorded a significant upper half mean length over the rest of the checks, viz., PA-183, DHY-286 and NH-615.

Uniformity index (%)

The highest uniformity index was recorded in check DCH-32 (87.30 %), followed by derivatives IS-2-1, IS-2-2 and IS-33-1. Derivatives IS-2-4 (85.65 %), IS-3-2 (85.35 %), IS-33-4 (85.65 %) and IS-43-5 (85.25 %).

Micronaire value (µg/inch)

The highest micronaire value was recorded in *arboreum* check variety PA-183 (4.56 µg/inch) followed by introgressed derivatives viz., IS-1-4 (4.28 µg/inch), IS-2-7 (4.27 µg/inch), IS-2-8 (4.27 µg/inch), IS-3-5 (4.27 µg/inch), IS-31-7 (4.37 µg/inch) and IS-32-9 (4.36 µg/inch).

Fibre strength (g/tex)

The highest fibre strength was recorded in derivatives IS-32-15 (30.70 g/tex), followed by derivatives IS-1-4, IS-2-1, IS-2-2, IS-2-4, IS-2-8, IS-11-5, IS-32-12, IS-33-4, IS-33-5, IS-36-12, IS-43-3, IS-43-5, IS-43-13, IS-44-1 and check DCH-32 (29.25, 28.75, 30.55, 29.65, 29.00, 29.15, 29.25, 29.35, 30.05, 29.70, 28.50, 29.50, 29.65, 29.45 and 29.10 g/tex), respectively.The hybrid check, DCH-32, recorded the highest upper half mean length (UHML) (32.05 mm), uniformity index (87.50 %) and finest micronaire (2.70 µg/inch). The highest fiber strength was recorded in trispecies derivatives IS-32-15 (30.70 g/tex) which was found superior over all the checks viz., PA-183 (26.45 g/tex), NH-615 (25.15 g/tex), DHY-286 (26.15 g/tex) and DCH-32 (29.10 g/tex) followed by introgressed trispecies derivatives viz., IS-2-1 (28.75 g/tex), IS-11-5 (29.15 g/tex), IS-32-12 (29.25 g/tex) and IS-33-5 (30.05 g/tex). Deodikar (1949) obtained similar results in their studies on introgression breeding.

Conclusion

The materials developed through introgression breeding in the present study are still showing instability for chromosomes even after 21 years. This material may be useful for students, cytologists and scientists for carrying out basic research in cotton, particularly the effect of genome interactions on total chromosome complement when two tetraploid species (*Gossypium hirsutum x Gossypium barbadense*) and one diploid species (*Gossypium arboreum*) are involved in the development of trispecies populations.

Morphological, yield contributing and fibre quality traits were found to be intermediate between *G. arboreum* and *G. hirsutum* checks, indicating introgression of traits from *G. arboreum, G. hirsutum,* and *G. barbadense*.

Four trispecies derivatives, viz., IS-2-1, IS-11-5, IS-32-12, IS-33-5 and IS-1-5, were found to be the most diverse for morphological and fiber traits, whereas IS-3-1 and IS-43-9 were found to be the most diverse and dissimilar, having a broad genetic base for the concerned fiber quality traits.

Conflict of interest

The authors declare that they have no conflict of interest.

References

Anonymous (2018). Department of textiles, Government of India.

Arif, M. J., Gogi, M. D. and Ahmad, G. (2006). Role of morpho-physical plant factors imparting resistance in cotton against thrips, *Thrips tabaci* (Lind). (Thripidae: Thysanoptera). *Arab J. Pl. Prot.* 24: 57–60.

Bashir, M. H., Afzal, M., Sabri, M. A., and Raza, A. B. M. (2001). Relationship between sucking insect pests and physico-morphic plant characters towards resistance or susceptibility in some new genotypes of cotton. *Pak. Ent.* 23 (1): 75–78.

Butter, N. S., Vir, B. K. and Kour, (1989). Morphological basis of resistance in cotton to the Whitefly *Bemisia tabaci. Phytoparasitic*. 17: 251-261.

Deodikar, G. B. (1949). Cytogenetic studies on crosses of *G. anomalum* with cultivated cottons. I (*G. hirsutum* x *G. anomalum*) doubled x *G. hirsutum. Indian J. Agric. Sci.* 19: 389–399.

Deshpande, L. A., Kokate, R. M., Kulkarni, U. G. and Nerkar, Y. S. (1991). Cytomorphological studies in induced tetraploid *G. arboreum* and its interspecific hybrid with tetraploid *G. hirsutum*. *Indian J. Genet.,* 51: 194-202.

Ding S., Libing L., Zhang B. and Ding S. P. (1999). Morphology and cytology of interspecific hybrid F_1 between the allotetraploid of (*G. arboreum* x *G. bickii*) F_1 and *G. barbadense. J. Zhejiang Agril. Univ.,* 25 (1): 31-35.

Dobzhannstkhy, (1941) .Genetics and the origin ofspecies. xviii+446 pp. Columbia University Press, New York.

Guljar, A., Arif, M. J. and Sanpal, M. R. Z. (2005). Population fluctuation of Jassid, *Amrasca devastans* (Dist.) in Cotton through morphophysical plant traits. *Caderno de PesquisaSér. Bio., Santa Cruz do Sul,* 17 **(**1): 71-79.

Kamdi, S. R., Meshram L. D. and Sushir K. V. (2006). Cytomorphological studies in interspecific hybrid *G. hirsutum x G. aridum*. *J. Cotton Res. Dev*., 20 (1): 5-8.

Malik, V. S. and Nandal, A. S. (1986). Screening of cotton varieties or germplasm for resistance against cotton jassid (*Amrasca biguttula)* (Ishida) and pink bollworm (*Pectinophora gossypiella*) (Saunders). *J. Haryana Agric. Univ.,* 16 (3): 290-293.

Mather, K., (1943). Polygenic inheritance and natural selection. *Biol. Rev.*18**:**32-64.

Mehetre, S. S., Aher, A. R., Patil, V. R. and Shinde, G. C. (2003). Cytomorphological studies in hybrid between haploid of *G. hirsutum* (L.) and diploid *G. arboreum* (L.). *Indian J. Genet. Pl. Breed.,* 63 (2): 137-142.

Mehetre, S. S., Aher, A. R., Patil, V. R. and Shinde, G. C. (2003 a). interspecific hybrids involving genetic male sterile line of *G. arboreum* and *G. thurberi*. *SABRAO J. Breed. Genet.,* 35 (2): 71-79

Meshram, L. D. and Tayyab M. A. (1991). A new interspecific hybrid between *G. hirsutum* (L.) and *G. thurberi* Fry. *J. Indian Soc. Cot. Improv.,* 16: 28-30.

Meshram, L. D. and Tayyab M. A. (1994). Cytogenetical studies in five trispecies hybrids in *Gossypium*. *PKV Res J.,* 18:73-77.

Muhammad J. A., Ijaz A. S., Saif U., Muhammad D. G. and Ashfaq S. M. (2004). Some morphological plant factors effecting resistance in cotton against thrips (*Thrips tabaci* L.). *Int. J. Agril. Bio.,* 6 (3): 544–546.

Panse, V. G. and Sukhatme, P. V. (1967). Statistical methods for agricultural workers, 2nd edition, Indian Council of Agricultural Research, New Delhi.

Quian Siying (1996). Morphological and cytological studies on interspecific F_1 hybrids of *G. hirsutum* with *G. aridium*, *G. lobatum, G. laxum* and *G. tumeri*. *Jiangsu J. agric. Sci.,* 12 (3): 10-14.

Ramamoorthy P. T. S. R. (2006). Production of interspecific hybrids between *Gossypium hirsutum* and jassid Resistant Wild Species *G. raimondii* and *G. armourianum. Cytologia,* **71** (4): 407–418.

Raza, A. B. M., Afzal, M. and Manzoor, T. (1999). Physico–morphic plant factors affecting resistance in new genotypes of cotton against sucking Soc. pp: 99–100, Pakistan, NARC, Islamabad

Saitwal, V. M., Mehetre, S. S., Sonone, A. H. and Gawande, V. L. (2003). Cytomorphology of F_1, F_2, backcross generations of interspecific Cross between *Gossypium arboreum* x *Gossypium anomalum. Cytologia*, 68 (4): 317–327.

Saravanan, S., Koodalingam, K. and Nagarajan, P. (2005). Cytogenetic investigation of triploid and hexaploid derivative involving *G. hirsutum* Var. MCU 12 and *G. arboreum* Var. PA 255. *Asian J. Plant Sci.* 4 (5): 507-509.

Sharma, H. C. and Agarwal, R. A. (1983). Role of some chemical components and leaf hairs in varietal resistance in cotton to jassid, *Amrasca biguttula* (Ishida). *J. Ent. Res.,* 7: 145-149.

Silow, R. A., (1941**).** The comparative genetics of *Gossypium anomalum* and the cultivated Asiatic cottons. *J. Genet.,* 42: 259-358.

Thombre, M. V. and Mehetre, S. S. (1981). Interspecific hybridization in genus *Gossypium* (L.). II. Cytomorphological studies in hybrid *G. hirsutum* haploid. (2n=2x=26, A_hD_h) and *G. thurberi* (2n=2x=26, D_1D_1). *Cytologia*, 46: 291-299.

Vanitha, K., Shivasubramanian, P., Sivasamy, N. and Amala Balu, P. (2007). Biophysical and biochemical aspects in wild species of cotton towards leaf hopper, *Amrasca biguttula* (Ishida). *J. Cotton Res. Dev.,* 21(2): 235-238.