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Hexaploid Cotton: Some Plant and Fiber Properties[1]

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ABSTRACT

Hexaploid cottons were made by crossing *Gossypium hirsutum* L. (Acala 44-10-1) and *Gossypium sturtianum* Willis. The chromosome number of the sterile interspecific hybrids was doubled with colchicine. The hexaploids were selected and grown for several years. Fiber and spinning data were collected for the first time from plants having more than 52 chromosomes. The hexaploid cotton fibers produced yarn with very high yarn strength.

Additional index words: **Interspecific hybrid, Colchicine treatment, Doubling of chromosome number, Hexaploid cotton, Fiber properties, Spinning performance, *Gossypium*.**

BEASLEY (1) described the unusual properties of a *Gossypium hirsutum* L. × *G. strutianum* Willis hybrid[3] whose chromosome number was doubled with colchicine. Among his comments were:

> This hexaploid differs greatly from American cultivated cottons since many of the *G. sturtii* characters are dominant. The capsules are smaller and the fibers are slightly shorter than those of the American parent. The shorter fibers were expected since *G. sturtii* has extremely short fibers . . . . An important point, however, is that the fibers of the hexaploid are smaller in diameter, apparently more uniformly thickened, and have fewer convolutions than those of the American parent.

Gossypium sturtianum Willis, a lintless wild cotton endemic to Australia, was known under the name of *G. sturtii* from 1863 until 1947, when Willis (8) pointed out that this name was illegitimate under the International Code of Botanical Nomenclature.

Saunders (6) published an excellent illustration of *G. sturtianum*. The flowers of this species are highly ornamental. They have mauve petals with a deeper mauve spot at the base. The whole plant is glabrous and covered with a bluish, waxy bloom.

Fryxell (3), in his revision of the Australian species of *Gossypium*, cited F. M. Mauer, who reported that *G. sturtianum* was the most cold-tolerant of the *Gossypium* species, and was immune to "gummosis" or bacterial blight.

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[3] *G. hirsutum* is an American cultivated cotton, a natural allotetraploid, 2N=4X=52, and *G. sturtianum* is an Australian wild cotton, a diploid, 2N=2X=26. The name *G. sturtii* was changed to *G. sturtianum* Willis in 1947.

Brown and Menzel (2), and Menzel and Brown (5), studied cytological and morphological characteristics of the *G. hirsutum* × *G. sturtianum* hexaploid, and some hexaploid × hexaploid hybrids. They have some interesting comments regarding fertility, chromosome pairing, mosaic formation and somatic reductions.

Apparently, no one besides Beasley (1) has reported on the fiber properties of a *G. hirsutum* × *G. sturtianum* hexaploid. Perhaps the difficulty of making a hybrid of this type has discouraged other researchers from further investigation of the fiber potential of this hexaploid. With the above information in mind, a project was initiated in Arizona to produce some hexaploid cottons to measure additional plant and fiber properties.

MATERIALS AND METHODS

Experimental Acala 44-10-1, (*G. hirsutum*), a selection out of the commercial variety A-44-10 was used as the female parent because of its good fiber properties and adaptation to Arizona. *G. sturtianum* was used as the male parent.

Crosses were made in 1963 using a modified version of the soda straw technique as described by Humphrey and Tuller (4). Several bolls were set, each containing several seeds. The seeds were germinated in the greenhouse. When the seedlings had developed two true leaves, the young shoots were cut off about 15 mm above the cotyledonary nodes. Absorbent cotton was wrapped around the cotyledonary node and saturated with 0.5% solution of colchicine. Each treated seedling was covered with a 400-ml glass beaker for 24 hours to maintain high humidity. When the cotyledonary buds started growing, they were examined periodically and all normal-appearing shoots were removed. Only thickened and coarse shoots were permitted to grow.

Micro-spinning tests and determinations of fiber properties were made when sufficient lint samples were harvested from the hexaploids. These tests were made at the U.S. Department of Agriculture Cotton Fiber and Spinning Laboratory, Knoxville, Tenn., and The University of Arizona Cotton Laboratory, Tucson, Ariz.

Fiber length was determined by Servo and Digital Fibrograph instruments. The upper half mean (UHM) length from Servo Fibrograph is theoretically a different measure of fiber length than the 2.5% span length from the Digital model, but both are similar in practical application. The UHM is a measure of the average length of the longer half of the fibers in a sample of cotton, whereas the 2.5% span length is a measure of the length spanned by 2.5% of the fibers in the sample. The mean (M) length is a measure of the average length of the fibers in a sample. The 50% span length is a Digital Fibrograph measure of the length spanned by 50% of the fibers in the sample (7).

Fiber strength was measured on both the Pressley Strength Tester and the Stelometer. The Pressley Index shows the number of pounds required to break a milligram of fiber of a given length. Determinations can be made at zero and 1/8 inch spacings. Results from the Stelometer are expressed as grams per tex (tex is a measuring unit for fibers, filament, and yarn based on weight in grams of 100,000 m of fiber or yarn). The Stelometer measurements are made at T_0 and T_1 to designate zero and 1/8-inch spacings. Fiber elongation E_1 measurements can be obtained in connection with the 1/8-inch gauge fiber strength test by using a Stelometer instead of the Pressley instrument. E_1 is the percentage elongation at break of the center 1/8-inch of the fiber bundle measured for T_1 on the Stelometer.

Fiber fineness was measured on the Micronaire and the Arealometer. The Micronaire reading is expressed as Micronaire units, the higher the number, the coarser the fiber. The Arealometer readings are expresesd as A values and D values. The value is expressed in terms of square millimeter per cubic millimeter of fibrous material. The higher the number, the finer the fiber. The D value measures the flatness of the fiber, the higher the value the more ribbon-like are the fibers.

RESULTS AND DISCUSSION

The colchicine treated hybrid seedlings of *G. hirsutum* × *G. sturtianum* flowered profusely in 1964, but set only a few bolls. Seed number in these bolls was low. An examination of the pollen mother cells showed that these plants had more than 52 chromosomes. (Cytological examination were made by J. E. Endrizzi, Professor and Head, Department of Plant Breeding, The University of Arizona, Tucson.) The exact number was difficult to determine. These plants were classified as hexaploids, but the possibility that they may be aneuploids was not ruled out. Seeds of the hexaploids were smaller, with shorter fibers, than those of the *G. hirsutum* parent, and agree with Beasley's description (1) of a similar hexaploid. The hexaploids resembled their Acala parent except for shorter internodes. These plants were glabrous with bluish-green leaves and had extensive monopodial branching. The flowers were considerably larger than those of the Acala parent, and the petals were brilliant reddish-mauve with a dark red petal spot at the base. The anther sacs were red.

Six hexaploid plants were grown in the greenhouse in 1965. Only three of these plants produced seeds.

Seventy-five plants were grown in the field in 1966 from seed harvested in 1965. Thirty-two plants were discarded at harvest because they failed to produce seed. The remaining plants were selected for further study. The seed cotton from the selected plants was ginned, and the seed was kept separate by individual plants. The fibers from one progeny (6X-3) were bulked to determine their properties. Fibers from the Acala 44-10-1 parent were harvested from an adjoining field on the University of Arizona Campbell Avenue farm for analysis. The fiber data and seed properties are shown in Table 1.

Seed size of the hexaploid was small and fiber length short, as compared to A-44-10-1, Table 1. The Micronaire reading of the hexaploid indicated coarser fiber than that of the Acala parent. The fiber strength (Pressley Index, 1/8 inch) was 30% stronger than that of the Acala parent. This supports Beasley's suggestion that fibers of the hexaploids would be stronger because they were more uniformly thickened and had fewer convolutions than those of the Acala parent.

A total of 194 plants was grown in the field in 1967 from seed harvested in 1966. The seeds were hand planted in the field on March 15, 1967. Observations on general growth showed that the hexaploids were more cold tolerant than the commercial varieties, Deltapine Smoothleaf (DpSL), Hopicala, and Pima S-2 planted in adjacent rows (DpSL and Hopicala are *G. hirsutum* and Pima S-2 is *G. barbadense*). Plants of the commercial varieties were pulled

Table 1. Laboratory data of fiber and seed properties for 1967, comparing a hexaploid cotton, Experimental 6X-3 and parental line A-44-10-1.

Property	Experimental 6X-3	Exper. A-44-10-1
Line percentage	39.0	38.1
Seed index, grams †	6.25	13.3
Lint index, grams ††	4.05	6.4
Fiber length (UHM), inches	0.89	1.07
Fiber length (M), inches	0.65	0.78
Uniformity ratio (M/UHM)	0.73	0.73
Fiber strength (P.I. 1/8")	4.42	3.36
Fiber fineness (micronaire)	4.70	3.60

* The University of Arizona Cotton Fiber Laboratory, Tucson, Ariz. † Weight of 100 seed †† Weight of lint from 100 seeds.

out as flowering began to avoid cross pollination. Flower counts were made daily from July 29 through September 1, 1967. The flower count was made to determine the flowering habit of the hexaploids. There was considerable variability from day to day; the flowering peak for the 1967 season occurred in mid August. This coincided with the normal flowering peak for Pima cotton grown on an adjacent field at the University of Arizona Casa Grande Overpass Farm (data for flower count not shown).

Seed cotton from each hexaploid was harvested and weighed. Fifteen of the 194 plants were discarded because of sterility. This higher rate of fertility indicated that selection for fertility was effective. Cotton from plants within a progeny row was bulked, and progeny rows which had similar characteristics were combined to obtain sufficient lint samples for microspinning tests. By this method, three samples were obtained. The check variety used for comparing the three samples of hexaploid cotton lint was Stoneville 213. These results are shown in Table 2. This, to the writer's knowledge, is the first time cotton fibers from plants with more than 52 chromosomes have been tested for spinning performance. This statement has been verified by Dr. Thomas Kerr (Leader, Cotton Quality Investigations USDA-ARS, Beltsville, Md.).

The three hexaploid cotton samples had fiber shorter than the check variety (Table 2). The hexaploids had a higher uniformity index. Micronaire readings for the hexaploids and the check variety were the same. Colorimeter (Rd) values for degree of brightness in terms of percentage reflectance, showed that the hexaploids had a lower value than the check variety. This means the hexaploids were not as bright in appearance. Hunter's +b values, also measured by the Colorimeter, indicated that the degree of yellowness of the hexaploids was greater than the check. Yarn strength of the hexaploids was 30 to 20% stronger than that of the check variety. This is significant since the fiber length of the hexaploids is much less than that of the check variety.

Additional fiber data were obtained from the U. S. Department of Agriculture Cotton Spinning Laboratory in Knoxville, Tenn. (Table 3). Fiber tests were made on ginned lint and drawing sliver. The data showed the hexaploids had fibers 20% shorter than the check, but the uniformity index of the hexaploids was higher. The high T_0 and T_1 readings of the hexaploids indicated extremely strong fibers. The Micronaire values, determined on ginned lint, showed that the fiber fineness was about the same, with the hexaploids having a slightly coarser fiber. The Arealometer A values determined on drawing sliver showed that the hexaploids 6X-3-1 and 6X-3-0 have finer fibers than the check variety. These differences in Micronaire values and the Arealometer A values may be due to differences in short fiber loss during processing. The D values of the hexaploids were lower than the check, with 6X-3-19 having a very low value. This suggests that the hexaploids have rounder fibers than the check. The high T_0 and T_1 readings plus other traits mentioned could help account for the strong yarn produced from a short fiber.

These tests showed that it is possible to produce spinnable yarn with interesting strength qualities from hexaploid cottons.

Table 2. Micro spinning test data for 1967, comparing three hexaploid cotton samples and a check variety.

	Experimental 6X-3-1	Experimental 6X-3-19	Experimental 6X-3-0	Stoneville 213
Fiber length				
50% span	0.43	0.42	0.47	0.44
2.5% span	0.92	0.92	0.96	1.07
Uniformity index,				
(50% × 100)/2.5%	46.0	45.0	49.0	40.0
Micronaire value	3.9	4.2	3.9	4.0
Reflectance (Rd)†	59.0	62.0	54.0	76.0
Hunter's +b‡	11.5	11.5	11.0	8.0
Yarn strength 22's§	136.0	143.0	130.0	103.0

* U.S. Department of Agriculture Cotton Fiber and Spinning Lab., Knoxville, Tenn.
† Rd Value is measured by the colorimeter and indicates the degree of brightness. It is in percent reflectance. ‡ Hunter's +b value is measured by the colorimeter and indicates the degree of yellowness. The values are in Hunter's +b units. § Yarn strength eorrected for yarn number of 27.0 tex in terms of standard skein.

Table 3. Laboratory fiber data for 1967, comparing three hexaploid cotton samples and a check variety.

Fiber properties	Experimental 6X-3-1	Experimental 6X-3-19	Experimental 6X-3-0	Stoneville 213
		Ginned lint†		
Fiber length(UHM), inches	0.82	0.84	0.88	1.05
Fiber length(M), inches	0.69	0.69	0.75	0.85
Uniformity ratio				
(M/UHM × 100)	85.0	83.0	86.0	81.0
Micronaire value	3.98	4.05	4.23	3.95
		Drawing sliver‡		
Fiber length(UHM), inches	0.85	0.87	0.86	1.05
Fiber length(M), inches	0.69	0.73	0.70	0.80
Uniformity ratio				
(M/UHM × 100)	80.0	84.0	81.0	77.0
Fiber strength (T_0)	47.8	49.0	48.5	35.2
Fiber strength(T_1)	30.3	32.0	31.4	16.8
Fiber elongation(E_1)	8.9	8.6	9.0	8.7
Arealometer (A)	512.0	495.0	517.0	496.0
measurement (D)	22.0	14.0	24.0	26.0

* U.S. Department of Agriculture Cotton Fiber and Spinning Lab., Knoxville, Tenn.
† Raw cotton lint before proeessing. ‡ Partly processed ling.

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