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DEVELOPMENT OF COMPACT COTTON STRAINS FOR HIGH LINT PRODUCTIVITY IN *GOSSYPIUM HIRSUTUM* L. I. BREEDING PROCEDURE AND SELECTION

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ABSTRACT

With a view to develop short-branch, high yielding, high ginning varieties with superior quality fibre so that 6–8 times the normal plant population could be accommodated, a unique procedure involving composite crossing among F_1 was followed. Initially, nine F_1 plants were crossed among themselves in all possible combinations. Intensive selection of plants in the population grown with seeds obtained by composite crossing (S_0 generation) having 1–3 noded short sympodia and repeated composite crossing between them resulted in the development of short-branch strains with no dried flowers, high ginning and superior fibre quality, which formed JK 400 series of cotton (*G. hirsutum* L.) varieties. Some of these strains produced 41.8 q/ha seed cotton under rainfed conditions with 36-47% ginning out-turn (GOT), 25–33 mm 2.5% span length fibre. Fibre strength, hand tested in the field before assessment in the laboratory, gave 8.19 to 9.36 PSI values with the fibre having 3.7–4.4 micronaire values. The breeding procedure and method of field selection are discussed.

Key words: Composite crossing, cotton, *G. hirsutum*, compact strains.

The low productivity of cotton in India is generally attributed to the fact that more than 75% of the area is rainfed in this country. However, even in states like Punjab and Haryana, where cotton is almost entirely grown under adequate irrigation, the yield levels are much lower than those reported from other cotton growing countries, including neighbouring Pakistan. One of the main factors affecting cotton yield adversely is low plant population (55,000/ha). The present cultivated varieties do not respond well to increased plant population per unit area [1–5], giving only 10–15% higher yield than with normal plant population. This is because the plant canopy of cotton varieties grown is pyramidal in shape, bearing long extended lower branches, thus, requiring wider spacing between rows. In USA, USSR, China and the Middle East countries like Egypt and Sudan, the population level in cotton fields is maintained at 100,000–120,000 plants/ha. While USSR has resorted to growing short-branch cotton varieties that enable machine harvesting for higher yields [6], better management of cotton crop in the USA has increased average lint yield from 44–66 q/ha. In the 1970s, attempts were made to develop "narrow-row cotton" in the USA [7–11]. It has been shown that increasing plant population to 275,000/ha increased lint yield of narrow-row cotton by 25%. Recently, at Akola in the Maharashtra State, variety 081 yielded 35% more seed cotton by raising plant population to 225,000/ha. But this variety has a tendency to produce long multinoded sympodial branches at wider spacings. The other method of increasing lint yield is by increasing ginning out-turn (GOT).

Singh and Santhanum [12] introduced cultivars from the USSR which produced 4–6 flowers in a cluster. But the PRS (progeny of Russian selections) strains, PRS 72 and PRS 74 (*G. hirsutum* L.) and SB 289 E and SB(YF) 425 (*G. barbadense* L.) introductions exhibit drying up of flower buds and young bolls which are retained on the plant till harvest, giving ugly appearance and increased trash content in the produce. Moreover, these genotypes are highly susceptible to jassids (*Empoasca bigutella bigutella*) and, therefore, do not give high yields. The nature of drying up of flower parts persists even in the segregating generations of crosses involving the PRS types and the local cotton varieties at Coimbatore and resulting in the evolution of variety 1412.

Therefore, a breeding method was developed so that the short branch habit is realised and drying up of flower parts eleminated. Plants having only 1–2 noded, short (10–12 cm) sympodial branches, would make it possible to accommodate 6–8 times plant population per unit area. Simultaneously, combining high GOT would ensure high lint yield in different fibre length groups. With a view to develop varieties yielding up to 50 q/ha seed cotton under rainfed conditions and 100 q/ha under irrigated conditions breeding work was initiated in 1971, the progress of which is reported here.

MATERIALS AND METHODS

Four strains of cotton (*G. hirsutum* L.), undergoing yield trials, viz., JK 97, JK 44, JK 79 and JK 125, were developed by the author by intermating selected F_2 plants of the cross CL 20 × Acala 5675 in accordance with a plan suggested by Dr. A. B. Joshi. The four varieties were used as agronomic base. Each of these was crossed with PRS 72 and PRS 74. A cross was also made between Stoneville 213 of USA and MCU 5 of Tamil Nadu (India). These nine F_1 were grown at Agricultural Research Station, Dharwad Farm in 1972 and composite crossed among themselves in all possible combinations. The flowers on F_1 plants were hand emasculated by thumb nail method so that emasculated anthers could also be collected. The anthers were thoroughly mixed and stored in Petri dishes overnight at room temperature. The next morning hand pollination was done using the pollen mixture on all the emasculated flowers. This procedure was repeated daily for 3 weeks. Seed cotton harvested from crossed bolls was bulked and ginned to obtain an 8-parent composite crossed seeds (CCS_O).

The first composite crossed seeds (I-CCS_O) were sown at normal spacing of 60 × 30 cm in July 1973 on an area of 0.4 ha accommodating a little more than 22,000 plants. The plants reached flowering stage at 60–68 days after sowing and observations were recorded between 80–90 days. A total of 262 plants having shorter than normal sympodial branches, i.e., plants with 3–4 noded sympodia and not more than 4 dried flowers/plant were selected and again composite crossed among themselves as described above. Thus, the selection II-CCS_O seeds were produced. The cycle of selecting plants with 1–3 noded sympodial branches and less than 3 dried flowers/plant and intermating them again was continued till IV-CCS_O seeds were obtained.

Since I-CCS_O and II-CCS_O plant populations were susceptible to jassids, a highly resistant and hairy strain D-33 (IARI, New Delhi) and variety Laxmi (Karnataka) were also included in the II-CCS_O cycle of crossing. Jassid tolerance was an additional criterion for selection of plants in III-CCS_O and IV-CCS_O cycles. From 1976 onwards, selection and intermating of plants within each selected plant-to-progeny row were continued. For this purpose intermating sister plants, within the same progeny was continued until compact cotton strains having 1–2 nodes/sympodium, no dried up flowers on the plant, jassid resistant, more than 50 g seed cotton producing, and possessing GOT above 40% and fibres longer than 24 mm were obtained.

RESULTS AND DISCUSSION

Evolution of short-branch, high yielding and high ginning cotton strains was the main objective of this breeding programme. Therefore, use of eight genetically diverse cotton strains in the first and second cycles of composite crossing and addition of two jassid tolerant donor genotypes in the third cycle, generated a wide range of recombinants in IV-CCS_O population. This method of composite crossing differs from the other methods followed to create variability in cotton [9, 13, 14].

Secondly, the large population of more than 22,000 segregants in each generation offered adequate opportunity for selection of plants with the desired characters. The uncrossed bolls of selected plants were used to assess GOT and fibre length (halo length) of the mother plants. It was also possible to select for high GOT and different fibre length. Fibres of seed cotton picked from each plant were hand tested to eliminate low ginning, nonuniform and low-fibre-strength types in the field itself. Mixed pollination of selected plants enabled accumulation and adding up of polygenes and gene complexes determining short-branch habit, high GOT and superior fibre quality.

Table 1. Mean, range and coefficient of variability for 6 characters in IV-CCS_O population of compact cotton genotypes

Character	Mean	Range	CV (%)
Jassid tolerance (grade)	2	1.3–2.8	16.8
Nodes/sympodium	2.1	1.6–3.8	12.5
Dried flowers/plant	3.1	2.2–6.7	31.6
Yield/plant (g)	56	37–92	28.3
GOT(%)	39.7	39.3–46.1	18.1
Halo length (mm)	27.2	24.6–33.1	20.2

In 1976, 328 IV-CCS_O plants with jassid resistance, short sympodial branches with 1–2 nodes, not more than 3 dried flowers, 50 g cotton yield and more than 40% GOT and 24 mm halo length were assessed. The range, mean and coefficient of variability (CV) for six characters are presented in Table 1.

None of the IV-CCS_1 plants was completely free from dried up flowers, although variability for this character was maximum. Since short-branch character was one of the main selection criteria, plants with fewer nodes/sympodium but not more than three dried flowers were also selected. Yield per plant was as high as 92 g (average 56 g) seed cotton/plant. Accumulation of polygenes determining GOT was evident from the fact that plants exhibiting as high as 46.1% GOT were available for selection and many of them had fibre length of about 30 mm. The CV for nodes/sympodium and GOT was rather low, indicating that these two characters would almost breed true in subsequent generations. The character values of the 10 top selections out of total 328 are listed in Table 2.

Table 2. Characters of ten best selections in IV-CCS_1 generation

Selection No.	Nodes per sympodium	No. of dried flowers	Seed cotton yield/plant (g)	GOT (%)	Halo length (mm)	Jassid grade (0–4)
112	2	3	92	43.4	28.4	1
146	2	2	81	44.1	29.3	1
210	2	3	76	42.5	33.1	1
214	1	1	63	43.9	28.6	1
239	2	2	73	40.3	32.2	2
285	1	2	58	46.1	30.5	1
330	2	3	76	44.3	29.7	1
353	2	2	59	45.8	28.7	2
391	1	1	64	43.0	31.6	1
410	1	1	70	45.4	30.5	1

Single plant progeny rows in the second selfed generation after fourth cycle of composite crossing (S_2) of the above 10 and 76 other plants were grown with the normal spacing of 60 × 30 cm in 1979, each family comprising 4 rows of 20 hills/row. The selection norms were revised depending on the combination of characters exhibited by different plants. Not a single plant totally free of dried flowers was detected. Therefore, plants progenies within each selected family were intermated to eliminate this undesirable character. Variability for yield, GOT and halo length was conspicuous. Therefore, the intermated population of each family was raised in the next year and individual plants with high GOT but low halo length were crossed again within family, a procedure repeated for five more generations. The tendency of flower drying was completely eliminated only after intensive selection and accumulation of desirable genes by intermating plants of the same family. Thus, 80 plants of family No. 10 were divided into two groups with differentiating plant characters as listed below.

Group I, having yield 80 g GOT 39%, halo length 30 mm, and two dried flowers/plant.

Group II, having 60 g yield, 46% GOT, 24 mm halo length, and one dried flower/plant.

The plants belonging to the two groups were intermated in the next year in all possible combinations following the pollen mixture techniques described above.

Ultimately, 40 outstanding plants were isolated in 1983 and numbered as JK 400 series. The short-branch and high yielding strains, JK 400 to JK 418 and JK 441, were tested in trials along with commercial check varieties Laxmi and Sharada, maintaining 333,000/ha plant population in the new strains and both 333,000 and 55,000/ha (normal) population in the checks. The spacing for planting seeds was 30 × 10 cm or 60 × 30 cm (normal). The trial was conducted with four-row plots and three replications. The yield and fibre quality estimates of a few outstanding selections are presented in Table 3.

Table 3. Performance of short-branch and compact cotton selections of JK 400 series (1984)

Strain		Seed cotton yield (q/ha)	GOT (%)	2.5% span length (mm)	Maturity coefficient	Micronaire value	PSI '0' gauge
JK 400		37.8	40.5	30.8	0.74	3.9	8.65
JK 405		33.2	40.5	31.4	0.73	4.1	8.43
JK 406		39.6	43.8	27.4	0.75	4.0	8.66
JK 408		41.8	40.5	31.0	0.71	3.8	8.32
JK 410		40.2	47.4	25.6	0.75	4.2	8.59
JK 411		31.7	42.4	26.8	0.70	3.7	8.73
JK 413		36.2	39.6	30.1	0.74	3.9	8.44
JK 415		30.3	39.0	30.4	0.71	3.9	8.19
JK 416		39.5	39.7	32.7	0.74	3.9	8.60
JK 417		30.0	39.3	30.2	0.71	4.0	8.10
JK 418		28.5	41.0	28.4	0.75	4.0	8.57
JK 440		40.5	38.0	26.7	0.71	4.4	9.36
JK 441		38.9	39.0	31.8	0.72	3.9	9.34
Sharada*	a)	18.5	40.6	24.1	0.73	4.5	8.06
	b)	23.1	39.8	23.2	0.74	4.4	8.05
Laxmi*	a)	15.3	35.5	25.4	0.65	3.6	8.21
	b)	20.8	34.5	25.1	0.68	3.7	8.10
CD (5%)		6.3	2.4	—	—	—	—

*Spacing 30 × 10 cm (a) and 60 × 30 cm (b).

It is evident that the short-branch compact cotton strains developed by the method of composite crossing in F_1 and intermating among selected plant progenies described, have given us as high as 41.8 q/ha yield of seed cotton under ample rainfall conditions (539 mm during crop period). The commercial check varieties appeared to have been adversely affected because of high population density, since their yield with normal crop density (55,000 plants/ha) was 5–5.5 q/ha higher than under high density (333,000 plants/ha). Varieties with normal branching habit. such as, Laxmi and Sharada generally do not respond to higher population [9, 15] and their yield may even decline under higher crop density [8]. The breeding method followed by us has resulted in varieties with outstanding yield as well as fibre quality. The manual testing of fibre strength in the field is quite reliable to the extent that fibres that can be broken will have less than 8.25 PSI value and such plants could be rejected in the field itself. This was confirmed by PSI tested values of 8.10–9.36 by the Fibre Quality Evaluation Unit, Dharwad. The GOT of strain JK 410 (47.4%) is the highest ever reported. Further selections in these strains resulted in improvement of yield to 43.6 q/ha, (JK 440–2–1) GOT 47.8% (JK 410–10), and PSI value 10.15 (JK 415–13) [15].

Another advantage of the short-branch compact cotton selections was their earliness. The total crop duration of these cotton strains in summer season (15th January–30th May) was 135 days as against 155 days in Sharada and 185 days in Laxmi. Although no special selection pressure was applied for earliness, the short-branch habit itself appears to have greatly reduced the period required for building up sufficient crop canopy. Fowler and Ray [10] also reported earliness in the narrow-row cotton crop under high population density.

The selected strains also exhibited variation for flower petal colour as well as leaf size. Selection was further applied to make them uniform morphologically. These selections are presently being tested in the All India Coordinated Cotton Improvement Project.

The technique of composite crossing of F_1 followed here for cotton improvement is different from the composites of *Zea mays* L. The method has helped in nearly achieving the objective of developing cotton strains that produce very high yields per unit area, high ginning and superior fibre quality in a directed manner within a period of 11–12 years (1972–1984). The factors contributing to this are: utilization of wide genetic base, intensive composite crossing among F_1 plants through four successive generations, intensive selection of plants for further intermating between plants of a family for five generations to accumulate polygenic complexes determining plant habit, jassid tolerance, short branch, high GOT and better fibre quality.

REFERENCES

1. I. P. S. Alhawat, N. J. Mudholkar and V. M. Sahni. 1973. Effect of fertilizer and population pressure on cotton. Indian J. Agron., **18:** 454–458.

2. S. Panchaksharaiah, R. D. Radder and S. V. Patil. 1974. Effect of plant population and fertilizers on growth and yield of Laxmi cotton (*G. hirsutum* L.). Mysore J. Agric. Sci., **8:** 39–46.

3. R. R. Iruthayaraj, R. Mayalasami and A. Chami. 1970. Yield performance of upland cotton to several spacing arrangements. Curr. Res., **8:** 69–72.

4. S. C. Jain, H. K. Srivastava, V. Chauhan and M. L. Sharma. 1981. Yield efficiency of Bikaneri Narma and variable planting dates, population dynamies and nitrogen levels in Chambal command area of Madhya Pradesh. J. Indian Soc. Cott. Impr., **6:** 86–88.

5. D. S. Nahara, M. S. Kairon, S. K. Agarwal and Vireshwar Singh. 1982. Effect of sowing dates, spacing and nitrogen levels on ancillary characters and seed cotton yield. Indian J. Agron., **27:** 347–352.

6. S. N. Kadapa and R. P. Bhardwaj. 1985. Cottcn breeding, seed production and other aspects in the Union of Soviet Socialist Republic Report on a visit to USSR, Dharwad: 182.

7. R. E. Briggs and I. L. Patterson. 1969. Narrow row spacing of cotton. Proc. Beltwide Cott. Prodn. Res. Conf. Memphis, USA: 102–103.

8. D. R. Buxton, R. E. Briggs and I. L. Patterson. 1977. Canopy characteristics of narrow row cotton as influenced by plant density. Agron. J., **69**: 929–933.

9. A. G. Douglas and J. A. Andrews. 1970. Narrow row cotton culture in Mississippi. Proc. Beltwide Cott. Prodn. Res. Conf., Memphis, USA: 61–62.

10. J. L. Fowler and L. L. Ray. 1977. Response of two cotton genotypes to five equidistant spacing pattern. Agron. J., **69:** 733–738.

11. S. S. Koli and L. G. Morill. 1976. Effects of narrow-row, plant population and nitrogen application on cotton yield and growth. Agron. J., **68:** 897–901.

12. Avatar Singh and V. Santhanum. 1963. A report on the visit to the USSR to study cotton production and breeding. Pub. Director Cotton Development, GOI, Bombay: 103.

13. H. L. Lewis. 1971. Concepts in narrow-row cotton production. Proc. Western Cott. Prodn. Conf., Dallas, USA: 7–8.

14. H. F. Jensen. 1970. A diallel selective mating system for cereal breeding. Crop Sci., **10:** 629–635.

15. S. N. Kadapa and E. S. Abraham. 1987. Raise lint productivity through compact cottons. The Indian Textile Journal, **XCVII**(10): 104–107.