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Selecting for Productivity Within a Strain of Cotton, *Gossypium hirsutum* L., in Three Environments

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Summary. The effectiveness of selecting cotton (*Gossypium hirsutum* L.) plants solely for productivity was examined in three climatic zones of the San Joaquin Valley. Individual plant selections (F_7) were made from the breeding line 12302 (later released as Acala SJ-1 cultivar) in 1965 at locations in the northern, western, and southern zones of the valley. Increased production of seed cotton was shown for selections in each zone when compared with the parental check in replicated trial in 1968.

Selecting at the northern zone resulted in a higher proportion of high yielding lines than was attained by selections at other zones. Observations indicated productivity in the northern zone of the valley may be closely associated with early maturity.

Fiber quality was also affected to a greater extent for the northern selections, with the more productive selections showing a greater reduction in fiber length.

These findings suggest that selecting plants or progenies in a marginal environment can aid in identifying variation due to cryptic variability that remains following pure line breeding in a favorable environment.

The breeding of Acala strains of cotton (*Gossypium hirsutum* L.) for the One-Variety District of California has been done at the U.S. Cotton Research Station, Shafter, California, since 1926. Until the 1960's, all plant selections and early-generation progenies came from the nurseries on the Shafter station. Screening trials for F_4 and later-generation progenies were initiated in 1953 at other San Joaquin Valley locations. Tests of preliminary strains have also been conducted at valley sites that differed considerably in climate, soil, and culture (Turner 1962).

Visiting researchers frequently raised the question whether greater progress for productivity (seed-cotton yield) might be made by selecting plants and progenies in and for specific valley environments. Is the breeding system at Shafter utilizing the maximum genetic variability present in a given strain of cotton? Perhaps some of the variability present, but obscured under optimum environment, would come to light if grown in some of the marginal climatic zones within this important cotton producing valley? The purpose of this paper is to report the first phase of a breeding-methods study on such questions.

Literature Review

Breeders have obtained different results from selecting within cultivars. Harland (1934) found he was able to make progress in yield of sea island cotton (*Gossypium barbadense* L.) by applying selection pressure solely on lint index with lines that had been self-pollinated for 17 years. The development of Empire and Acala cultivars reported by Ballard (1950) and Harrison (1950) followed Harland's procedures in most respects. However, Simpson and Duncan (1953) found yield was reduced when a pure line selection method was used to select within four cultivars. Manning (1963) has been successful in making genetic advances for yield within an upland cotton cultivar by using a selection index technique.

Materials and Procedures

"Breeder's Seed" of the experimental cotton strain "12302" (F_7 generation) was used to plant blocks of approximately 5,000 plants at three locations in 1965. This strain was being increased and tested in the 1964 to 1966 period, previous to its release as the Acala SJ-1 cultivar in 1967 (Turner and Cooper 1968). The three locations, Chowchilla, Five Points and Arvin were chosen to represent distinct climatic, soil and cultural differences found in the northern, western and southern zones of the San Joaquin Valley.

Genetic variability for boll, seed and fiber properties had been detected in the F_5 and F_6 generations of the 12302 strain, both in the valley strains tests and the standard breeding nursery. This was as expected since the 12302 strain originated from a composite of five plants in an F_4 progeny of 1962. Selection of 80 highly productive plants was made from the block in each zone during October 1965. Also, 20 plants chosen at random were sampled to serve as the parental check in laboratory determinations. A 10-boll sample from each selected plant was hand picked for gin and fiber laboratory determinations and to provide seeds for 1966.

Seeds of the 80 selections from each zone were used to plant 80 progeny rows; 10 m in length, 1 m wide with 12 plants per m of row, in their respective zones in 1966. Four parental check rows were included (Acala SJ-1 seed), making a total of 84 rows at each zone. The 1966 rows were harvested, and seed-cotton weights were obtained. The yield data were used to eliminate one-half of each group. The seed cotton from the 40 selected progenies

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plus checks was saw-ginned. Laboratory determinations were made on the fiber for upper half mean length (U.H.M.), mean length (M), uniformity (M/UHM expressed as a percent — U.R.), strength (tenacity in gr/tex at 3.25 mm gauge length — T_1), elongation at break (E_1) and fineness (Micronaire value). The seeds were used for continuation of the study.

In 1968, replicated test plots were established in the three zones. The test in each zone consisted of the 40 selected progenies of 1966 from that zone, plus the parental check. The quantity of seed limited the plots to three replicates of single row plots, 14 m long × 1 m wide, with 10 plants per m of row. At harvest, seed cotton yield was obtained from each of the 123 plots in each zone. Due to the consolidation of seed cotton samples from the three replicates before ginning, fiber quality data were obtained from a single sample for each progeny.

Results

Mean values for the boll, seed, and fiber properties of the plant selections and checks harvested in 1965 are shown in Table 1. The data indicated that selections produced larger bolls, more seed per boll, and higher lint percentage than the checks. Some of the fiber properties, however, were adversely affected by the selection pressure. Fiber length (UHM & M) was shorter and micronaire reading increased for the selections in all zones. On the other hand, the selection pressure apparently had little influence on fiber strength (T_1) or elongation (E_1).

Mean values for determinations made on the 1966 progenies are presented in Table 2. The mean yields for the 40 more productive progenies are also compared with those for the 40 discarded progenies.

The spread between selected and discarded progenies for yield of seed cotton (kg/plot) was much wider in the northern zone. All of the 40 retained progenies at the northern (N) zone produced more seed cotton/plot than the checks. The mean fiber length (M) and length uniformity (U.R.) were lower for the selected progenies than for the parental check in all zones. Micronaire readings were higher at the N and S zones, but were lower than those of the check

Table 1. *Boll, seed, and fiber data means — 1965 plant selections*

Test zone	B. S.	S. I.	S/B	L. P.	U. H. M.	M	UR	T_1	E_1	Mic.
North										
80 selections	6.9	13.6	33.7	34.4	1.27	1.06	84	21.4	7.7	3.88
20 checks	6.7	14.0	31.2	33.8	1.29	1.11	86	21.5	7.8	3.77
West										
80 selections	7.8	13.5	37.0	36.2	1.26	1.07	85	22.4	7.0	4.65
20 checks	7.5	13.7	35.9	35.6	1.28	1.08	85	21.8	7.8	4.36
South										
80 selections	7.7	14.2	35.0	36.9	1.27	1.09	86	23.3	7.1	5.01
20 checks	7.5	14.5	33.4	36.5	1.28	1.11	87	24.0	7.1	4.86

B. S. = Boll size (grams)
S. I. = Seed index (grams per 100 seed)
S/B = Seeds per boll
L. P. = Lint percent
U. H. M. = Upper half mean (inches)
M = Mean (inches)
UR = Uniformity ratio (%)
T_1 = Tenacity (gr/tex)
E_1 = Elongation (%)
Mic. = Micronaire

Table 2. *Mean values — 1966 progenies evaluated*

Test zone	SC/P Kg/plot	S. I. grams	G. T. %	U. H. M. inches	M inches	UR %	T_1 gr/tex	E_1 %	Mic. index
North									
40 selected	3.05	13.8	32.6	1.15	0.95	82.6	23.6	6.6	4.46
4 checks	2.29	14.2	31.9	1.17	0.99	84.6	24.7	6.9	4.25
40 discarded	2.27								
West									
40 selected	3.64	13.6	31.9	1.19	0.97	81.5	23.1	7.1	4.45
4 checks	3.33	13.9	31.2	1.18	0.99	83.9	22.2	7.1	4.62
40 discarded	3.00								
South									
40 selected	3.62	14.0	32.4	1.10	0.87	79.1	23.9	6.8	4.55
4 checks	3.54	14.3	31.6	1.11	0.89	80.2	24.1	6.7	4.42
40 discarded	3.09								

SC/P = Seed cotton per plot
S.I. = Seed index
G.T. = Gin turnout
U.H.M. = Upper half mean
M = Mean
UR = Uniformity ratio
T_1 = Tenacity
E_1 = Elongation
Mic. = Micronaire

Table 3. *Seed-cotton yield — mean values (1968)*

North zone				West zone				South zone			
Selection	Kg/plot	Selection	Kg/plot	Selection	Kg/plot	Selection	Kg/plot	Selection	Kg/plot	Selection	Kg/plot
N 50	4.71	N 6	4.49	W 54	6.14	W 11	5.60	S45	5.95	S74	5.30
N 60	4.67	N 17	4.48	W 74	6.14	W 45	5.60	S18	5.84	S27	5.28
N 12	4.66	N 62	4.48	W 48	6.10	W 32	5.59	S80	5.83	S62	5.26
N 19	4.63	N 47	4.46	W 70	6.10	W 6	5.59	S43	5.73	S77	5.25
N 53	4.63	N 74	4.45	W 61	6.07	Check	5.58	S47	5.68	S2	5.25
N 23	4.62	N 43	4.45	W 7	5.96	W 58	5.58	S36	5.68	S17	5.23
N 51	4.62	N 2	4.42	W 20	5.90	W 13	5.56	S26	5.66	S40	5.22
N 71	4.60	N 26	4.40	W 3	5.89	W 50	5.56	S23	5.64	S64	5.22
N 15	4.59	N 65	4.30	W 51	5.80	W 44	5.54	S81	5.62	S10	5.21
N 45	4.59	Check	4.23	W 24	5.80	W40	5.54	Check	5.49	S68	5.19
N 59	4.59	N77	4.22	W49	5.79	W59	5.53	S41	5.49	S54	5.19
N14	4.58	N22	4.21	W64	5.79	W22	5.49	S1	5.46	S49	5.18
N76	4.58	N32	4.16	W77	5.78	W79	5.46	S42	5.45	S12	5.14
N52	4.57	N38	4.15	W15	5.78	W80	5.45	S78	5.43	S71	5.11
N8	4.57	N75	4.10	W9	5.75	W30	5.42	S25	5.43	S50	5.10
N49	4.56	N40	3.94	W82	5.75	W23	5.42	S79	5.43	S55	5.10
N5	4.55	N55	3.92	W52	5.65	W26	5.41	S15	5.40	S3	5.06
N61	4.51	N69	3.73	W39	5.65	W68	5.40	S58	5.38	S66	5.06
N42	4.51	N16	3.72	W1	5.63	W4	5.39	S13	5.38	S24	4.99
N71	4.50	N13	3.55	W56	5.63	W38	5.35	S31	5.37	S6	4.99
N30	4.50			W34	5.62			S4	5.30		
L.S.D. at 5% = 0.37				L.S.D at 5% = 0.41				L.S.D. at 5% = 0.34			

at the western zone. Seed indexes were lower, and gin turn-out was increased for the selected progenies as compared to the check in all zones. Fiber-length values were at a lower level for all samples from the S zone, partly as a result of prolonged fiber exposure. The plots were not harvested until mid-December.

The replicated yield tests of 1968 provided the best estimate of productivity for the selections made in the three valley zones. Seed-cotton yields from each zone are shown in Table 3. Some selections produced significantly higher yields than the check in each zone. However, there were far more selections at the N zone that exceeded the yield of the parental check than did the selections at the other zones. Field observations indicated the more productive N zone selections were more determinate in growth and earlier-maturing than the parental check.

No replicated data were obtained for seed and fiber traits, because the seed cotton from all replicates for each selection was pooled to facilitate seed-saving. A summation of the mean values for the 40 selections, in comparison to the check, is given in Table 4. These values indicate that fiber length uniformity, and fiber fineness, were changed more by the selection pressure at the N zone than at the other zones.

Discussion

Although the San Joaquin Valley is considered to be a relatively homogenous cotton growing area, plant growth and development proceed at a much slower rate in the northern zone and seed and fiber maturation are delayed by lower temperatures in the fall. This is further aggravated by the water requirements of soil types prevalent in that zone. Frequently, growers in the northern zone have only 35% of their cotton harvested when the first frost and winter rains occur, while growers in the southern or western zone may have 80% harvested at the same date.

The information presented herein indicates the Acala SJ-1 cultivar was more responsive to selection pressure for productivity in the northern zone than in the west or south zones of the valley. The phenotypic contrast between the productive selections and the parental check for earlier maturity and determinate growth was noted only in the northern zone. Fewer selections at the western and southern zones

Table 4. *Mean values for 6 traits — 1968 screening tests*

Test Zone	G.T. %	U.H.M. inches	UR %	T_1 gr/tex	E_1 %	Mic.
North						
40 selections	32.5	1.18	84.3	21.2	7.0	4.26
Check	32.2	1.20	85.0	21.6	6.9	4.07
West						
40 selections	32.4	1.21	86.2	22.9	6.5	4.41
Check	32.0	1.22	86.0	22.9	6.6	4.35
South						
40 selections	30.8	1.22	86.1	23.2	6.5	4.21
Check	30.6	1.22	86.0	23.4	6.4	4.23

G.T. = Gin turnout; U.H.M. = Upper half mean; UR = Uniformity ratio; T_1 = Tenacity; E_1 = Elongation; Mic. = Micronaire exceeded the parental check in seed cotton yield, but even these displayed no earlier maturity or determinate growth habit. Furthermore, the fiber properties were influenced to a greater extent in the northern zone selections.

Assessing the influence that seasons had upon the breeders judgment is difficult in this study. Almost ideal conditions prevailed in each zone in 1965 when the primary selections were made. Production problems were present at both the northern and western locations in 1966. Unconsciously, an emphasis may have been placed upon early maturity in screening the progenies that were tested in 1968 at these two zones. The genetic, environmental and genetic × environmental influences need to be estimated. This requires a thorough testing of selections from the three zones in all zones over several seasons.

Since all selection activity in the development of Acala SJ-1 was done in the southern zone (Shafter) of the valley these results were not too surprising. One point that resulted from this selection effort deserves special attention. The highly desirable compact, early fruiting habit that characterized one of the parents of Acala SJ-1 was recovered in many of the lines selected in the northern zone. We had never been able to recapture this trait in the development of the cultivar at Shafter, nor from the western or southern zone selections in this study.

These results suggest fringe environments may be quite useful in breeding efforts for detecting cryptic variability that fails to be exposed under more ideal conditions. In this case, early maturing compact plant types with high productivity were obtained only in the northern zone where natural selection would favor such a combination. Yields are often depressed in the western and southern zones of the San Joaquin Valley when early maturing genotypes are tested.

These results suggest cryptic variability within a breeding line may be expressed more often in a marginal environment. The marginal environment allows the expression of characteristics which are masked in the favorable environment — at "home" base. Breeders might well consider selecting and evaluating breeding material in fringe environments to more fully exploit variability that is of cryptic nature.

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