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An Approach to Hybrid Cotton as Shown by Intra- and Interspecific Crosses[1]

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AROUND the year 1920, results from experiments on the value of hybrid corn were not too encouraging. However, today the majority of the corn in the U. S. is raised from hybrid seed. Experiments to date do not suggest a very bright future for hybrid cotton. Corn is different from cotton in some respects that make it more adaptable to hybridity. In the first place, the corn pollen is windblown, while cotton pollen is insect borne. Also, corn is largely cross-pollinated, while cotton is largely self-pollinated. One female flower in corn produces several hundred seeds, while one flower in cotton produces at most some fifty seeds.

Hybrid cotton may have a chance in certain locations, where up to 50% of natural crossing takes place in the

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field (15, 1a). In other locations where there are few bees, natural crossing is about 2% to 4% (1, 17).

Hybrid cotton awaits proof of combining ability between strains, varieties, or species of cotton and the development of a method of dispersion of the pollen or a method of actually making the cross in an economical fashion. At the present time, there is a gametocide (2) which produces partial pollen sterility. As its use is more fully understood, part of the problem may be solved.

In the matter of combining ability, much remains to be proven (3, 7, 9, 10, 13, 15, 16). In cotton, like other crops, yield is the important character. For a hybrid cotton to be successful, the F_1 must not only produce a high yield, but must have a combination of genes for the characters of high quality of fiber.

In countries where frost dates determine the length of the growing season, practical production of hybrid cotton may be in the distant future, but in tropical countries it may be a near possibility. In Peru, where cotton can be cultivated as a perennial, it is possible by using cuttings and transplanting to produce a hybrid (F_1) cotton on a commercial scale. The purpose of this article is to report the results of an experiment on 20 intraspecific crosses, 2 interspecific crosses, and several pure strains of cotton.

Remarks on Previous Work

Loden and Richmond (10) have reviewed the literature previous to 1951 on natural crossing and on hybrid vigor in cotton. Most of the earlier work on this subject involved crosses of *G. hirsutum* and *G. barbadense* and, more specifically, American upland and Egyptian varieties. In most cases, the hybrid vigor was measured by differences involving certain plant or fiber properties. Such differences were very small. In general, *G. barbadense* and *G. hirsutum* crosses produce a very large F_2 plant of very little practical value (21). But specifically, there were differences in certain characters, such as number of nodes, length of internode, general vegetative growth, number of 5-lock bolls and many other characters.

Height of plant is a character generally accepted as being greater in F_1 than in parents in crosses between *G. barbadense* and *G. hirsutum*. However, it is important only if the length of internodes has not increased (21). A cotton plant will grow tall when insects or other factors have caused it to shed its fruit. In Peru this is especially true, for there are many causes of shedding of squares, bolls and even small branches (20). While increased quality would be desirable in a hybrid, only the maintenance of the quality is necessary. This can be accomplished by using only good quality strains to produce the hybrid cotton. Even if this is done, fiber properties and spinning tests must be made of the hybrid to be certain that it has a good spinning value (19).

Some good results have been obtained from several experiments in both yield and quality in certain hybrids (13, 14). To be successful, the varieties which would do best in a hybrid cotton would be those which have been proven to have good combining ability to the point of being better than the control variety by a significant amount and better than the best parent. The increase of lint must be sufficient to pay for the extra expense incurred in its production. Such strains would be the product of a lengthy testing program for both yield and quality and would, thus, be more likely to produce a uniform F_1.

Some unpublished work was done in New Mexico on hybrid cotton involving our 1517 strain of *G. hirsutum* and certain Pima strains, *G. barbadense*, which yielded some encouraging results (21). However, hybrids between Pima and upland varieties usually give plants which are large and not so desirable. The procedure for making the crosses and other details of this work were similar to procedures used in Peru except that the plots consisted of only 5 plants. The results of the work with 2 parents and 5 crosses are shown in Tables 1 and 2. These results show small to large increases of crosses over the strains. No significant increase in yield over the 1517 parent was found, but all crosses were significantly better than the Pima parent. Quality characters of the crosses were significantly better than the 1517 parent and as good as, if not better than, the Pima parent.

The results of other research favorable to the success of hybrids between *G. barbadense* and *G. hirsutum* were published in bulletin form (3). This work shows that in fiber length, strength and fineness the hybrids are better than or as good as the barbadense parent. The 1517 or *G. hirsutum* parent had an upper half mean of 1.19 inches while the Pima 32 *G. barbadense* had 1.43 inches, but the crosses ranged from 1.42 to 1.55 inches. In uniformity ratio the crosses all were better than the parent. In fineness all crosses resembled the Pima parent. In strength of fiber the crosses were intermediate between the two parents. These data would indicate a good spinning behavior of the hybrid. For a successful hybrid cotton, the yielding ability of 1517 with the character of fiber of Pima would be very acceptable.

Table 1—Varietal means of the yield characters of parent and hybrids tested in New Mexico (21).

	Bolls per plant	Lint percent	Lint per boll	5 plant lint yield
1517C	23.26	40.4	2.60	302.6
Pima S. 1	21.49	37.1	1.26	136.3
1517C × Pima S. 1	41.86	35.5	1.59	332.0
1517C × Pima 32	39.00	33.7	1.38	266.3
Mesilla Valley × Pima S. 1	55.37	31.3	1.31	366.0
9094 × Pima S. 1	46.77	35.0	1.72	407.4
9553 × Pima S. 1	42.66	33.1	1.62	339.9
Average crosses	45.13	33.72	1.52	342.32
Average strains	22.375	38.75	1.93	219.45
LSD .05	11.16	1.49	0.14	98.5
LSD .01	15.04	2.01	0.19	119.4

Table 2—Varietal means of the quality characters of parents and hybrids tested in New Mexico (21).

	Fiber length, upper half mean	Fiber fineness, micrograms per inch.	Fiber elongation	Fiber strength	
				Tenacity	Pressley index
1517C	0.99	3.47	5.30	2.11	8.21
Pima S. 1	1.02	3.04	6.49	3.00	9.68
1517C × Pima S. 1	1.17	2.63	6.49	2.80	9.39
1517C × Pima 32	1.21	2.59	5.63	2.83	9.81
Messilla Valley × Pima S. 1	1.28	2.64	6.59	3.09	10.26
9094 × Pima S. 1	1.19	2.86	6.43	2.75	9.05
9553 × Pima S. 1	1.23	2.90	5.79	2.93	9.62
Average crosses	1.216	2.72	6.186	2.88	9.626
Average strains	1.055	3.26	5.895	2.56	8.945
LSD .05	0.04	0.29	0.73	0.21	0.45
LSD .01	0.05	0.39	1.01	0.29	0.59

MATERIALS AND METHODS

Crosses were made by using soda straws (6) and by emasculation of the upper half of the style or, in case of branched styles, the whole staminal column. Flowers which were to open the next day were used for both the male and female parents of the cross. Procedures were worked out to cross a large number each day during the height of the flowering season in January, February, and March.

Crosses were made between certain advanced strains in our regular Tangüis breeding program (20) at this Institute. Exceptions to this were the Acala 1517C from New Mexico, an upland type, *G. hirsutum* and the 4737 Tangüis strain, *G. barbadense*, planned for the advanced test but placed in a propagation block for selection purposes only because of a fiber defect. The initial plan was to make all possible crosses among several of our best strains, crossing a large number of flowers to get enough seed for a comprehensive test. At the end of the crossing season, it was found that there was not enough seed of all crosses for the experiment. As a result, the experimental trials included a control strain SNA 248 (5, 11), the strains used in the crosses, and certain other good strains. Therefore, this hybrid experiment planted in the spring of the 1959–60 season was composed of 36 entries designed for a 6×6 lattice. Because of some irregularities found in planting, the analysis was made on a randomized block basis. Included in the entries were 2 interspecific crosses involving 2 of our Tangüis strains, 4737 and 5042, and Acala 1517. The principal differences in these two strains, besides general species characteristics, is that Tangüis is a coarse long-fibered cotton, while 1517C is a fine and medium-stapled cotton. The former has a large 3-lock boll, while the latter has a large 5-lock boll. Both cottons are capable of high yields with the greater potential being that of the Acala strain (5). The other 20 crosses used are intraspecific, *G. barbadense*, and involve advanced strains of Tangüis which have been bred for high yield and high quality (20). The pure strains composing these crosses were also included in the test with the exception of two: 5015 and 5039. Of the 3 strains involved in the interspecific crosses, only one of the strains, 5042, appears as a separate entry. The 4737 had been discarded because of a fiber defect, and the 1517C was not adapted as a commercial crop in Peru. Therefore, this hybrid test was composed of 2 interspecific crosses, 20 intraspecific crosses, and 14 strains derived from single selected plants.

The experiment was planted in September 1959 and harvested in April 1960. Each plot consisted of one row, 4 meters long, with a row spacing of 1.10 m. There were 6 replications. A good stand was obtained and the season was normal with generally favorable field conditions. A significant F value was obtained from an analysis of variance.

The characters: percent lint, lint index, boll weight, fiber strength, fiber fineness, length of fiber, and length uniformity were measured on samples from 3 replications of the experiment. Methods used in these determinations have been described previously (19, 20).

The cotton was harvested in two pickings. The weight of lint was calculated from samples which were taken of each plot of 3 replications for determination of the other characters. When these samples were ginned, the percent of lint was used to convert seed cotton into lint. The percentage of the control is shown for each entry of both first picking and total yield. The percent of control is also shown for the difference required for significance.

RESULTS

The results are shown in Table 3. Significant differences were obtained. In first-picking yields, which indicated the earliness factor, 12 crosses were significantly better than the control strain, SNA 248. In total yield, only two crosses were significantly better than the control. These latter were interspecific crosses 4737×1517C and 5042×1517C. The 5042 is a good advanced strain of Tangüis not as yet in general production. In this test, 5042 did not yield significantly better than the control. In other experiments, 5042 was somewhat better in yield than SNA 248, while in other experiments it was about the same in total yield. The 5042 was early in all experiments.

In the first picking, the 2 interspecific crosses doubled the yield of the check strain, while 9 of the intraspecific crosses were significantly better than the control. Of the 22 crosses, 10 were at the top in first-picking yield and in total yield. These crosses have resulted in good plants in numerous other crosses made and grown at the Institute. The plants have a very good combination of vegetative and fruiting branches, are fairly tall but not exessively so, and bear mostly 5-lock bolls. In the F_1 generation they resemble more the Acala type but in F_2 they resemble more the Tangüis with only a very few Acala-type plants.

The yields as shown in the table are good yields, varying for the crosses from 470 to 1028 pounds of lint per acre at first picking, and 901 to 1458 pounds as a total yield. The pure strains yielded from 394 to 641 pounds at first picking and totals of 697 to 1159 pounds of lint per acre. The best interspecific cross differed from its nearest strain competitor, 6202, in total yield by a significant difference of 299 pounds of lint per acre.

Another very important advantage that a hybrid (F_1) cotton would have over ordinary cotton would be its uniform lint quality. In hybrid cotton, every plant would be genetically uniform for all the characters of yield and quality if the parents were homozygous for these characters. This should produce bales of cotton uniform in all the fiber properties and, in turn, would produce even-running cotton in spinning and a high quality textile. This would be a tremendous advantage in marketing cotton and in the manufacture of cotton products.

As far as quality of fiber according to measurements made in this experiment, the two interspecific hybrids are fine, having micronaire values of 3.2 and 3.4, tenacity values of 2.43 and 2.50, with a uniformity of length on

Table 3—First-picking and total yields of interspecific and intraspecific crosses, some of their parents, and related advanced strains. Crop 1959–60 at Instituto de Genetica, La Molina, Lima, Peru.

Strain or hybrid	First picking, lb./acre			Total yields, lb./acre		
	Seed cotton	Lint cotton	% control lint	Seed cotton	Lint cotton	% control lint
5042 × 1517C	2741	1028	216	3889	1458	138
4737 × 1517C	2530	911	191	3978	1432	135
4175 × 3636	1996	820	172	3173	1304	123
4175 × 5015	1740	717	151	3001	1236	117
3636 × 4816	1848	702	147	3171	1205	114
4175 × 3958	1922	767	161	3009	1201	113
4175 × 2603	1877	738	155	3043	1196	113
4175 × 4810	1924	752	156	3031	1185	112
4175 × 4816	1800	709	150	2964	1168	110
3636 × 3958	1876	677	142	3207	1158	109
6202	1545	637	134	2814	1159	109
2603 × 3958	1773	667	140	3032	1140	108
5015 × 4810	1784	685	144	2949	1132	107
2603 × 5015	1356	632	112	2831	1110	105
3958 × 4810	2086	772	162	2974	1101	104
3958 × 4816	1983	743	156	2942	1103	104
5042	1506	604	127	2709	1086	103
3958 × 5015	1541	596	125	2790	1080	102
4810 × 4816	1856	681	143	2912	1069	101
4810	1682	641	135	2814	1070	101
4818	1690	617	130	2931	1070	101
2595	1319	516	107	2745	1065	101
SNA	1215	476	100	2703	1060	100
3636 × 5015	1447	576	121	2598	1034	98
6363	979	394	83	2513	1010	95
5039	1474	604	127	2413	989	93
6390	1261	517	109	2350	963	91
4816	1506	556	117	2592	957	90
3958	1405	502	105	2672	954	90
3636 × 2603	1281	494	104	2471	954	90
3636 × 4810	1363	518	109	2474	940	89
5015 × 4816	1190	470	99	2387	943	89
4816 × 2603	1433	535	112	2416	901	85
4175	1159	459	96	2250	891	84
2603	1221	443	93	2347	852	80
3636	1062	400	84	1849	697	66
LSD .05	545	210	44	684	264	25

the pressley sorter of 19%, 1¼″ cotton, and 31 and 32% of cotton less than 1″ long. In Peru, the market calls for a much coarser cotton than the interspecific hybrid. The hybrid is equal in fineness to 1517 and adaptable to much better quality textiles than the Tangüis of Peru. Several of the hybrids of Tangüis×Tangüis are significantly better as to earliness than the check. This is important because of certain areas where there are frequent water shortages and cool growing seasons.

Remarks on a Plan for Hybrid Cotton Production

Before embarking on a commercial hybrid cotton production program, it is planned to duplicate the cross 5042×1517C and produce enough seed so that it can be tested in one of the advanced strain tests on a larger scale than the hybrid experiment under discussion. The gametocide FW 450 will be used in addition to producing a large amount of crossed seed by hand. A planting of this F_1 seed will then be made on one of the farms in the Rimac valley. At planting time, next year, these plants will be cut off to provide a ratooned or second year crop. The branches will be used as cuttings (8) to enlarge the acreage. At the present time it is obviously not known how large a production can be achieved in this way. The plan appears reasonable because cotton can be used as a perennial and can be grown several years before being plowed up and planted over. In Peru, where very few pollination insects are found, it does not seem feasible to try to pollinate a field for commercial production by using insects (15). However, with the use of a gametocide to produce male sterility (2, 4, 12, 18) one might develop a method of collecting large amounts of pollen and dusting the female plants. It should be developed along with the regular improvement program. Such a regular program should include progeny, preliminary, and advanced strain tests and provide material from irradiation, interspecific, and intraspecific hybridization.

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