Published November, 1980

Performance of Paired Nectaried and Nectariless F_3 Cotton Hybrids[1]

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ABSTRACT

Amino acids and sugars are removed from cotton, *Gossypium hirsutum* L., nectaries in large amounts by various insects. Nectariless [2(ne_1ne_2)] cottons conceivably could utilize this photosynthate to increase yield or fiber quality. The possibility of identifying superior nectariless populations motivated this study. The objectives were to: 1) evaluate a method of detecting nectariless populations that contained favorable interactions of yield and fiber quality with nectariless genes and 2) determine the magnitude and frequency of occurrence of these favorable interactions.

Nectaried (Ne) and nectariless (ne) hybrid populations were derived from crosses of DES 24-8ne with 19 diverse strains (S) at Stoneville, Mississippi. In 1976, 8 pairs and in 1977, 11 pairs of Ne and ne F_3 hybrids were each grown in six replications at two Stoneville locations. Averaged over both years, nectaried plants had 1.8% larger seeds and 1.6 and 0.9% longer fiber (50 and 2.5% span length, respectively) than nectariless plants. In 1977, boll size in nectaried plants was 1.5% larger than in nectariless ones. No other significant differences or trends were detected. These results reinforced previous studies indicating no strong deleterious association between nectariless and yield and fiber properties. No significant Ne vs. ne × S interactions were detected for lint yield, but small significant interactions were detected for lint percentage in 1977 and 2.5% span length in both years. Breeders should therefore not expect any large increases in yield due to the ability of nectariless plants to utilize the nectar photosynthate for agronomic purposes. However, the detection of favorable small interactions for lint percentage and fiber length suggested small advances in germplasm development.

Additional index words: Gene action, Yield, Fiber quality, Host-plant resistance, *Gossypium hirsutum* L.

THE nectariless trait was transferred into Upland cotton, *Gossypium hirsutum* L., from the wild species *G. tomentosum* Nutt. ex Seem. Meyer and Meyer (7) determined that this trait is conditioned by two recessive genes ne_1 and ne_2. Meredith (4) reviewed the many cotton insects, both beneficial and harmful, influenced by the nectariless trait. Considerable amounts of nutrients can be removed by insects feeding on nectar. For example, honey bees (*Apis mellifera* L.) were reported by Butler et al. (1) to remove 3.4 kg/ha of nectar/day from 'Pima Sl,' *G. barbadense* L., in Arizona. The nectar volume in Pima is greater than that in Upland cotton, but the sugar concentration in Upland cotton is approximately twice that of Pima. Hanny and Elmore (3) isolated 24 amino acids from cotton nectar and reported that amino N constituted an average of 0.04% of the extrafloral nectar. Evidently cotton nectaries are a substantial sink for photosynthates.

In other crops, the manipulation of morphological traits has sometimes increased yields. For example, Qualset et al. (8) increased yields of barley (*Hordeum vulgare* L.) 16.3, 23.0, and 8.4% compared to awnless with Full-, Half-, and Quarter-awned isolines, respectively. In cotton, previous studies (4, 5) with near-isogenic nectarized and nectariless cotton indicated no major differences in yield or fiber quality as long as insect pests were controlled by insecticides. These near-isogenic nectariless cottons were produced by backcrosses with established cultivars. If a special genetic system exists in cotton that would allow nectariless to utilize the nectar photosynthate in a useful agronomic way, it was probably not present in the small sample of nectarized cultivars used for recurrent parents. To backcross nectariless into many genetic backgrounds would require considerable time. It would also result in nectariless strains being developed from cultivars

[1] Contribution from USDA, SEA, AR, Cotton Physiology and Genetics Laboratory, Stoneville, MS 38776 in cooperation with the Mississippi Agric. and For. Exp. Stn. Published as Journal Paper No. 4471 of the Mississippi Agric. and For. Exp. Stn. Received 12 May 1980.

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Table 1. Mean squares for lint yield, yield components, and fiber properties for 1976 cotton parents and nectaried (Ne) and nectariless (ne) F_3 hybrids.

Source	df†	Lint yield‡	Lint§	Boll size¶	Seed index§	Span length§ 50%	Span length§ 2.5%	Fiber strength	Elongation§	Micronaire¶
		kg/ha	%	g	g	mm	mm	mN/tex	%	
Location = L	1	751**	23	662	9	18	276*	1,660**	9	810
Replications = R	2	116**	431**	1,678	45*	656**	1,016**	222	38*	495
Strains = S	7	101**	1,402**	6,112**	187**	111*	994**	2,919**	40**	2,755**
S × L	7	33*	135**	1,056	26	7	18	41	12	550
Error a	14	15	24	946	11	37	32	72	9	286
Sub-plots	3									
Parents = P	1	9**	9,875**	9,433**	1,796**	85**	44	8,161**	597**	9,653**
P vs. F_3	1	3	685**	17,931**	316**	4	233**	70	121**	18
Ne vs. ne	1	0	6	64	138**	131**	262**	57	0	110
Sub-plots × L	3									
P × L	1	1	21	985**	113**	29*	8	238	26	144
P vs. F_3 × L	1	1	72*	218	1	1	29	14	4	488
Ne vs. ne × L	1	4	0	33	6	10	3	4	0	64
Sub-plots × S	21									
P × S	7	85**	773**	2,222**	98**	29**	454**	1,373**	100**	1,728**
P vs. F_3 × S	7	15**	11	1,777**	57**	18	44**	61	20	197
Ne vs. ne × S	7	5	10	250	8	13	27*	54	19	270
Sub-plots × S × L	21									
P × S × L	7	8	21	230	12	13	15	15	24	156
P vs. F_3 × S × L	7	1	16	298	6	11	8	48	14	183
Ne vs. ne × S × L	7	4	7	225	10	8	13	72*	22	100
Error b	48	5	12	208	11	12	12	32	16	162

*,** Significant at the 0.05 and 0.01 probability levels, respectively. † Degrees of freedom (df) for lint yield are 10, 70, and 240 for replications, error a, and error b, respectively. ‡ Mean square × 10^{-3}. § Mean square × 10^2. ¶ Mean square × 10^4.

that had a physiology compatible with nectaries. In crops where hybrids are used commercially, a test-cross is frequently used to test for lines that produce favorable yield responses. The objectives in this study were to: 1) test a method for detecting favorable interactions of nectariless and genetic backgrounds without going through the backcross procedure; 2) test the likelihood that some favorable interactions of genetic backgrounds and nectariless exist in cotton.

MATERIALS AND METHODS

Eight cultivars or strains were crossed with DES 24-8ne at Stoneville in 1974. These eight were 'Earlystaple 7,' 'Atlas 66,' Del Cerro 183, DES 04, 'DES 24,' 'DPL 523,' 'Delcot 277 BBR,' and 'Tamcot SP 37.' The eight F_1's were selfed at the winter increase nursery at Iguala, Mexico in 1975. For each segregating population in 1972, about 2,100 plants spaced about 15 cm apart on 1-m rows were grown at Stoneville. Nectariless and nectaried plants were identified. From each cross seed bulks were assembled from about 130 nectariless plants and about 1,975 nectaried plants. In 1976, nectariless and nectaried bulks and their parents were grown at two locations near Stoneville. The experimental design was a split-plot with six replications. Four sub-plots consisted of the nectariless and nectaried F_3 bulks and the two parents used to produce the hybrid populations. Eight whole plots comprised the eight different cross populations. Each sub-plot was one row, 1 × 16 m. Planting dates were 15 April and 5 May. Nectaried bulks were rogued to remove the one-twelfth expected nectariless plants, and nectariless rows were rogued to remove plants whose parents might have been misclassified.

In 1977, two similar experiments were planted near Stoneville, but contained 11 cultivars and strains. These 11 were 'DES 56,' 'DES B8-32,' P25, Stoneville 733, 'Coker 421,' B550, TH 149Sm₂, Coker 71-511, PD3-249, Q_1, and La 72-16. The 11 crosses were made in 1975; F_2 seed was produced in Iguala in 1975 to 1976; the nectaried and nectariless bulks were produced in 1976. As in 1975, about 130 nectariless and about 1,975 F_2 nectaried plants were identified from each cross to produce respective bulks of nectaried and nectariless F_3 seed. Each sub-plot was one row, 1 × 12.2 m. Planting dates were 15 April and 10 May. Plots were again rogued to remove offtype plants.

All 1976 and 1977 plots received weekly applications of dicrotophos [dimethyl phosphate ester of (*E*)-3-hydroxy-*N*,*N*-dimethyl= crotonamide], 115 g/ha a.i., beginning the 1st week in June and ending the 1st week of July. These applications were made to reduce the influence of early season insects, primarily tarnished plant bug, *Lygus lineolaris* (Palisot de Beauvois).

Seed cotton yield/plot was determined from one machine harvest made in mid-October of each year. A 50-boll sample was taken from each plot prior to harvest. In each test, the samples from replications 1, 2, and 3 were bulked to form one composite sample and those from replications 4, 5, and 6 were bulked to form another. Lint percentage by weight was determined from these samples as lint/seed cotton × 100. Lint percentage was multiplied by seed cotton yield to obtain lint yield/plot. Boll size was estimated by average weight in g/boll. Seed index was estimated by weighing 100 seed from each composite sample.

Fiber length, strength, and micronaire determinations were made from the composite lint samples at the USDA, SEA, AR Cotton Quality Laboratory, Univ. of Tennessee, Knoxville.

For statistical tests, the usual analysis of variance method was used for a split-plot design at two locations. In addition, the three degrees of freedom for sub-plots were partitioned into three orthogonal comparisons, as follows: 1) variation among the two parents within a sub-plot; 2) the mean of the two parents vs. the mean of the two F_3 populations, one nectaried and one nectariless (a test for heterosis and dominance): 3) the mean of the nectaried F_3 vs. that of the nectariless F_3. This third comparison, nectaried vs. nectariless, is of primary interest in this study.

RESULTS AND DISCUSSION

Mean squares from the analyses of variance for lint yield, yield components, and fiber properties in 1976 and 1977 are given in Tables 1 and 2, respectively. Similar trends are evident for both years. Significant mean squares were detected for almost all characteristics for strains (S), DES 24-8 ne vs. other parent (P), P vs. F_3 mean (heterosis), P × S, and P vs. F_3 × S. These large mean squares indicated that a broad range of genetic types different from DES 24-8 ne were used in this study.

Table 2. Mean squares for lint yield, yield components, and fiber properties for 1977 cotton parents and nectaried (Ne) and nectariless (ne) F_3 hybrids.

Source	df†	Lint yield‡	Lint§	Boll size¶	Seed index§	Span length§ 50%	Span length§ 2.5%	Fiber strength	Elonga-tion§	Micro-naire¶
		kg/ha	%	g	g	mm	mm	mN/tex	%	
Locations = L	1	27,181**	10,820**	111,505**	123**	468	1,694**	747**	473**	53,098**
Replications/L	2	220**	394	464	49	149	93	56	124	2,657
Strains = S	10	268**	1,199**	11,602**	490**	42	494**	1,151**	562**	2,652*
S × L	10	126**	106	410	10	15	29	85	49	431
Error a	20	23	47	393	8	18	21	59	61	426
Sub-plots	3									
Parents = P	1	12,223**	7,641**	3,705**	2,353**	339**	0	9,866**	4,932**	13,850*
P vs. F_3	1	68*	864**	10,294**	314**	68*	11	12	415**	123
Ne vs. ne	1	5	2	2,053*	53*	46*	29*	98	9	822
Sub-plot × L	3									
P × L	1	191**	143**	280	1	35	0	52	36	1,208
P vs. F_3 × L	1	19	1	176	16	8	0	69	20	43
Ne vs. ne × L	1	3	0	660	6	16	1	5	26	23
Sub-plot × S	30									
P × S	10	236**	411**	2,812**	184**	45**	205**	457**	100*	1,141**
P vs. F_3 × S	10	33*	89**	1,756**	14	6	26	79**	90	122
Ne vs. ne × S	10	14	65*	304	8	15	44**	50	25	284
Sub-plot × S × L	30									
P × S × L	10	23	70**	180	12	9	12	52*	38	417
P vs. F_3 × S × L	10	7	31	404	6	11	15	34	14	317
Ne vs. ne × S × L	10	17	13	280	8	14	16	27	17	74
Error b	66	13	26	322	8	11	15	25	46	253

*,** Significant at the 0.05 and 0.01 probability levels, respectively. † Degrees of freedom (df) for lint yield are 10, 100, and 330 for replications, error a, and error b, respectively. ‡ Mean square × 10^{-3}. § Mean square × 10^2. ¶ Mean square × 10^4.

Table 3. Mean lint yield, yield components, and fiber properties for DES 24-8ne, test parents, and nectaried and nectariless F_3 populations.

Population	Lint yield	Yield components: Lint	Yield components: Boll size	Yield components: Seed index	Fiber properties: Span length 50%	Fiber properties: Span length 2.5%	Fiber properties: Strength	Fiber properties: Elonga-tion	Fiber properties: Micro-naire
	kg/ha	%	g	g	mm	mm	mN/tex	%	
1976									
DES 24-8ne	602	36.7	5.18	9.9	13.38	29.44	193	8.71	3.40
Mean 8 parents	567	34.2	5.43	10.9	13.61	29.61	215	6.77	3.65
Nectaried F_3	591	35.0	5.55	10.9**	13.68**	30.00**	204	7.54	3.53
Nectariless F_3	590	35.0	5.53	10.6	13.39	29.59	202	7.56	3.50
1977									
DES 24-8ne	1,115	38.2	5.83	10.8	13.74	29.13	174	9.22	4.05
Mean 11 parents	932	36.3	5.70	11.8	14.14	29.12	196	7.72	4.30
Nectaried F_3	1,051	36.8	5.96*	11.6*	14.14*	29.23*	187	8.13	4.22
Nectariless F_3	1,042	36.8	5.87	11.5	14.00	29.12	184	8.20	4.16

*,** Nectaried F_3 significantly greater than nectariless F_3 at the 0.05 and 0.01 probability levels, respectively, as indicated by the F test.

The comparisons of most interest were nectarized vs. nectariless (Ne vs. ne) and Ne vs. ne × S. We will not discuss the Ne vs. ne × L and Ne vs. ne × S × L interactions because generally they were small relative to the other mean squares. Significant Ne vs. ne differences were detected for boll size, seed index, and 50 and 2.5% span length in either 1976 or 1977 or in both years. The magnitude of these differences is evident in Table 3. Nectarized F_3 had significantly larger seed and longer lint both years. On a 2-year average, seed were 1.8% larger and 50 and 2.5% span length were 1.6 and 0.9% longer, respectively, for the nectaried than for the nectariless F_3 plants. In 1977, boll size was significantly larger (1.5%) for the nectaried than for the nectariless F_3 plants. The small decrease in fiber length agreed with the results of Meredith et al. (5).

The design of this study is similar in principle to that of a study of the combining ability of various hybrids with a common inbred tester parent. In the present case, DES 24-8 ne was used as the tester parent and was crossed with 19 genetically diverse strains to produce 19 nectaried and 19 nectariless hybrids. A favorable interaction of Ne vs. ne × S would suggest a compatible genetic background from which improved combinations of nectariless and agronomic and fiber properties might be selected. Of particular interest would be the results for lint yield. The only significant (P = 0.05) nectaried vs. nectariless yield comparison detected was for the two Earlystaple 7 F_3 hybrid populations, which yielded 459 and 517 kg/ha of lint, respectively. Because we expect 1 out of 20 comparisons to yield significance due to chance alone, (Type I error) this 1 case out of 19 comparisons does not suggest that a significant Ne vs. ne interaction was detected. These yield results suggested that it will not be easy to find a strong favorable genetic interaction with nectariless. The major difficulty in using this method is that, while a positive yield interaction with nectariless might exist in a population, it might not be detected due to segregation at the many loci that influence yield.

It is evident that this method can produce significant Ne vs. ne × S interactions because lint percentage in 1977 and 2.5% span length both years showed significant mean squares. Of the yield components commonly measured, lint percentage usually has the highest positive association with lint yield. Nectaried and nectariless PD3-246 hybrids were significantly different, with average lint percentages of 39.0 and 37.9, respectively. Conversely, lint percentage of nectaried La 72-16 hybrids, 37.0%, was significantly lower than that of nectariless La 72-16, 38.0%. While the nectariless F_3 population averaged 0.9% shorter 2.5% span length, the average responses of the 10 comparative populations varied considerably. Six nectariless populations had significantly shorter (0.55 mm) fiber: Del Cerro 183, DES 04, DPL 523, Tamcot 37, B 8-32, and TH 149. One, B 550, had significantly longer fiber, and the remaining 12 showed no significant differences.

This study reinforced previous studies (4, 5) that indicated no strong deleterious associations of the nectariless trait with agronomic and fiber characteristics. On the other hand, results were disappointing because no large Ne vs. ne × S interactions were detected. Either the method is not sufficiently sensitive to detect such interactions or no large interactions exist in the broad range of genetic material studied. In a previous study, Elmore et al. (2) reported no evidence that nectariless cottonseed would be a recipient of unused N or amino acids from cotton nectar. They found no differences in N and amino acids of cottonseed between eight nectaried cultivars and their nectariless isolines. As Meyer and Meredith (6) have suggested, favorable interactions with *G. tomentosum* genes might best be expressed in *G. tomentosum* cytoplasm. At the initiation of this research, however, no such stable germplasm has been developed. Small but potentially useful interactions of Ne vs. ne × S were detected for lint percentage and 2.5% span length. These results indicate that cotton breeders should not expect to find large favorable interactions with nectariless easily, but they may be able to capitalize on several smaller interactions.

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