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Origin and Inheritance of Nectariless Cotton[1]

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CULTIVATED Upland cotton, *Gossypium hirsutum* L., has leaf, extrafloral, and floral nectaries. The nectar secreted attracts many insects and provides an important food for them. A nectary is usually found on the midrib on the lower side of each leaf. (Figure 1). Extrafloral nectaries are commonly found below the bracts (Figure 2) and also between and inside the bracts. Floral nectaries are located between the sepals and petals. (These have not been studied in the plant material reported in this paper.) *G. tomentosum* Nuttall is a wild cotton species, native to Hawaii, which has no leaf or extrafloral nectaries. *G. hirsutum* and *G. tomentosum,* tetraploid species with 2n = 52 chromosomes, produce a fertile F_1 hybrid.

Among the many interesting genetic markers which appeared in plants derived from hybrids of *G. hirsutum* × *G. tomentosum,* the absence of leaf and extrafloral nectaries was selected for transfer to Upland cotton. Rather early in the transfer program, C. L. Rhyne, Jr.[3] suggested that

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Figure 1—(Left) Midrib of leaf of nectariless cotton. (Right) Midrib of leaf of Upland cotton, showing nectar exuded by nectary on lower surface of midrib.

Figure 2—(Left) Bracts subtending boll of nectariless cotton. (Right) Bracts subtending boll of Upland cotton, showing extrafloral nectaries producing nectar.

besides being a useful genetic marker, the lack of nectaries might be important in the control of insects which depend on nectar for food. Stocks lacking leaf and extrafloral nectaries were given to entomologists and geneticists. Recent work by Lukefahr and Rhyne[4] indicates that populations of cabbage loopers and cotton leafworms were greatly reduced in caged experiments comparing nectariless cotton with an ordinary variety. D. F. Martin,[5] in a recent personal communication, reported that the number of pink bollworms was about half as great on plots of nectariless cotton as on plots of cotton with normal nectaries. These experiments encourage the belief that the nectariless character can be important in breeding for resistance of cotton to a number of insects. Since this character is potentially of considerable economic importance and of great interest to cotton breeders, results obtained in the program to develop nectariless strains of Upland cotton are reported.

MATERIALS AND METHODS

G. tomentosum was the source of the nectariless character. Due to the photoperiodic behavior of this species, the original cross with Upland cotton had to be made in the greenhouse. Z106, a doubled haploid of Upland cotton of the Stoneville type, was used to make the original cross and to make the first and second backcrosses to Upland cotton. M8948, a doubled haploid of the Deltapine type, was used to make the third and fourth backcrosses to Upland cotton. The use of doubled haploids reduced genetic variability in the Upland parent to a minimum and permitted the detection of small effects from the donor species.

The first backcross was made in the greenhouse by pollinating Z106 with pollen of the F_1 hybrid (*G. tomentosum* × Z106). The first backcross generation was grown in the field in 1955 and the most productive plants were moved into the greenhouse in the fall. Selection of these plants was not based on the presence or absence of nectaries. Self-pollinated seed and seed for the second backcross generation were produced during the winter and grown in the field in 1956. Three plants in the selfed progenies had no leaf or extrafloral nectaries; one nectariless plant had bolls; the other two plants were photoperiodic. Many plants in the selfed progenies had few and/or small nectaries. The most productive plants with either a few small nectaries or no nectaries were brought into the greenhouse in the fall for self-pollination and further backcrossing.

By 1957 the nonflowering and unproductive features derived from *G. tomentosum* had been reduced enough so that selfing and backcrossing of plants without nectaries could be carried out in the field. The best nectariless plants in these selfed progenies from the second backcross to Z106 were crossed with M8948. The seeds from this cross were planted at the tropical winter garden at Iguala, Mexico, where the plants were self-pollinated during the winter of 1957–1958.

In 1958 the selfed seeds from Iguala of the third backcross to Upland cotton were planted in progeny rows at the Delta Branch Experiment Station. The plants with nectaries were pulled out and the numbers of plants with and without nectaries were recorded for each row. The plants were first counted when most of them were about one foot high; every leaf on every plant was examined for nectaries. Since plants with small, inconspicuous leaf nectaries occasionally produce some nectar, examinations were made early in the morning when dew was present and nectar was clearly visible. The plants were examined a second time when flower production was general. At this time a general examination for nectaries could be quickly carried out by spanning the base of the stalk with both hands and glancing at the lower surface of the leaves as the hands were drawn toward the top of the plant. A shiny drop of nectar is easy to see, and the thickening of a vein around a nectary is conspicuous, particularly in a population in which nectaries are rare. Self-pollination of the most productive nectariless plants produced true-breeding strains. Crossing these plants with M8948 produced the fourth backcross to Upland cotton. The fourth backcross plants were self-pollinated in Iguala during the winter of 1958–1959 and the selfed progeny grown at Stoneville in 1959. Crosses were made between nectariless plants and several plants of the fourth backcross generation to determine the segregation in a cross between heterozygous and nectariless plants. In 1959, plants lacking nectaries in the F_2 and backcross progenies were scored as in 1958.

RESULTS

The results from the selfed progenies from the first and second backcrosses were not particularly useful in establishing the inheritance of the nectariless character. The nonflowering characteristic of *G. tomentosum* and abnormalities associated with segregating of interspecific hybrids caused difficulties in growing and scoring the plants. Difficulties of this kind are common in early generations of interspecific hybrids.[6]

Plants in the selfed progenies from the third and fourth backcrosses were scored and the results are presented in Table 1. The selfed progeny from the third backcross to

[4] Lukefahr, M. J. and C. Rhyne. Effects of nectariless cotton on populations of three Lepidopterous insects. Econ. Entomol. 53: 242–244, 1960.

[5] Leader, Pink Bollworm Investigations, Brownsville, Texas.

[6] Harland, S. C. The genetics of cotton. Part I. The inheritance of petal spot in New World cottons. J. Genetics 20:365–385. 1929.

Table 1—Segregation for leaf and extrafloral nectaries in selfed and backcross cotton progenies.

Generation	Plant segregation		Segregation ratio	χ_2	P
	Nectaries	Nectarless			
(A) Selfed progeny from:					
3rd backcross to Upland	2644	202	15:1	3.27	.05-.10
4th backcross to Upland	10635	718	15:1	0.11	.50-.95
(B) Backcross progeny to nectarless from:					
4th backcross to Upland	1340	397	3:1	4.26	.01-.05

Upland fits a theoretical 15:1 ratio for plants with and without leaf and extrafloral nectaries, respectively, although the excess of plants in the nectariless class approached the .05 level of significance. Experience has shown that during a short season or under poor growing conditions, some plants which do not develop nectaries produce selfed progenies containing plants with and without nectaries. It is known that this situation existed in this progeny and that some plants classified as nectariless were under-developed plants which did not express their genotype for nectary production.

The selfed progeny of the fourth backcross shows a very good fit to the expected 15:1 ratio. In this case the population involved 11353 well-developed plants and misclassification due to lack of penetrance was apparently avoided.

The backcrossed progeny to nectariless, from the fourth backcross to Upland, deviated from the expected 3:1 ratio and the .05 level of significance. In this case there was a deficiency in the nectariless class. These plants were not well-developed, but no explanation is offered for this discrepancy other than chance deviation.

DISCUSSION AND SUMMARY

The ratios obtained from the self-pollinated progeny of the third and fourth backcross generations justify the hypothesis that the inheritance of nectariless in this material is determined by two pairs of recessive genes. The symbols *ne*-1 and *ne*-2 are proposed for the two recessive genes producing the nectariless condition when both are homozygous, with *Ne*-1 and *Ne*-2 designating the dominant alleles.

The earliest strains of nectariless cotton released to entomologists and other workers were agronomically inferior to recent nectariless lines. After each backcross this material comes closer to commercial Upland cotton varieties in yield, boll size, and fiber properties. Advanced lines will be offered for research and breeding purposes whenever sufficient seed is available.