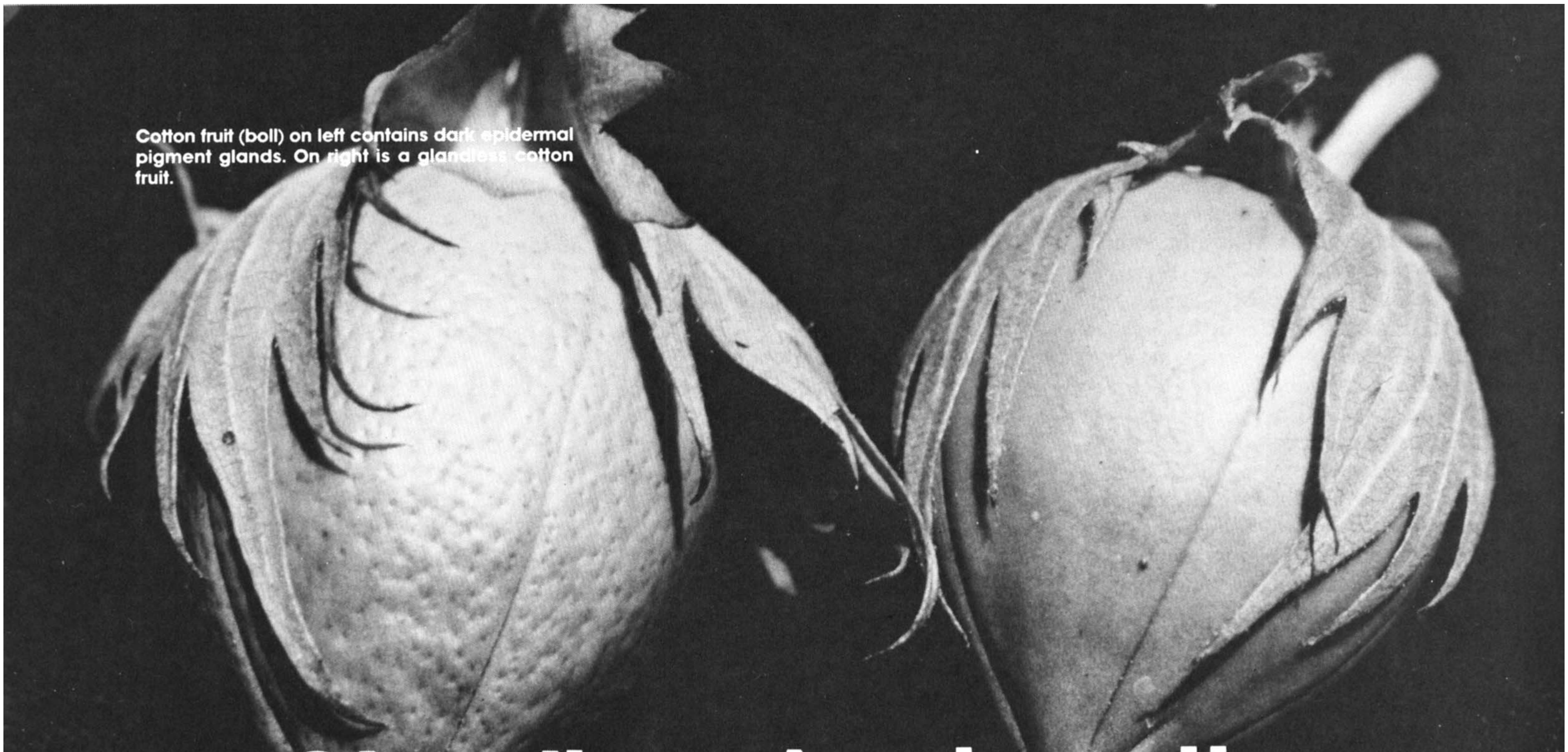

Cotton fruit (boll) on left contains dark epidermal pigment glands. On right is a glandless cotton fruit.

Glandless Acala cotton: more susceptible to insects

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Commercially grown Acala cottons (*Gossypium hirsutum* L.), like most other species of the genus *Gossypium*, have evolved an effective chemical resistance that deters most plant-feeding animals. The biologically toxic component is a group of related, secondary plant metabolites known as terpenoids. Gossypol, the best known of these terpenoids, is a polyphenolic yellow pigment closely associated with the epidermal glands present on all aerial plant parts as well as in the cottonseed. Most commercial cottonseed contains about 1 percent gossypol, depending on variety and environmental conditions. Expensive chemical and physical procedures are used to remove gossypol from cottonseed products destined for use as food for nonruminant animals.

In 1959 McMichael, in California, bred an American upland cotton free of pigment glands and their associated gossypol. Following this discovery, the cottonseed industry became very interested in gland-free cottonseed as an inexpensive source of concentrated protein for man and animals. Glandless seed would also reduce the cost of producing cottonseed oil.

Since then, private and public organizations have conducted considerable research to develop commercial cotton varieties yielding glandless seed. A glandless Acala cotton has been developed at Shafter that is well suited to growing conditions in California's San Joaquin Valley, but we have found, as have scientists across the nation, that glandless cotton is more susceptible than glanded to damage by many species of plant-feeding animals.

To evaluate the interactions between glandless Acala cotton and the San Joaquin Valley insect fauna, we conducted numerous laboratory and field experiments using Dr. Hyer's isogenic glanded and glandless Acala cottons. (Isogenic cottons were bred to be genetically identical except for the presence or absence of pigment glands.)

Laboratory tests

Greenhouse tests were conducted to compare the growth, survival, and nymphal emergence of lygus bugs (*Lygus hesperus* Knight) on isogenic glanded and glandless lines of Acala 4-42-77 and SJ-1. Nymphs individually confined for one week to glandless cotton plants had survival and growth rates nearly double those of nymphs confined to the isogenic glanded line (table 1). The presence of gossypol or some other terpenoid substance associated with pigment glands is probably responsible for the greater resistance in the glanded isolines.

Field cage tests

In the field, isogenic glandless and glanded SJ-1 plants were caged separately and infested with 48 lygus females per cage. The bugs were kept in the cages for five weeks, after which, gross population increase was determined by fumigating the cages and counting the nymph and adult bugs. More than twice as many lygus bugs were present on the glandless cotton (371) as on the glanded (149) (table 2).

Field free-choice test

To evaluate the effect of glandless cotton on the natural arthropod fauna under typical field conditions, we conducted experiments in the field using plots eight rows wide and 60 feet long (approximately $^{1}/_{3}$ acre per plot). Two pairs of isogenic glanded and glandless cotton—Acala SJ-1 and Acala 4-42-77—were utilized. Arthropods in these plots were sampled weekly.

The numbers of predatory insects and spiders did not differ statistically on glanded and glandless cotton (table 3), although glandless lines consistently tended to have a higher predator density than did the glanded lines.

Lygus bug infestations were again significantly larger on glandless than on glanded isolines (table 3). However, response of leafhoppers (*Empoasca* spp.) was unexpected—their numbers were lower on glandless lines than on glanded. The reason is unknown.

Grower-managed field tests

The final test of a new cotton line is, of course, how well it performs under grower management. Large replicated plots (7 to 12 acres per plot) of Dr. Hyer's Acala G8160 glandless cotton and commercial Acala SJ-2 glanded cotton—planted side by side—were established on four private farms and managed by the growers. As expected, the smaller yields of glandless cotton were consistently associated with increased lygus bug damage as compared with glanded cotton (table 4).

Conclusions

The present glandless cottons are capable of supporting larger populations of lygus bugs, thereby sustaining greater damage and yield reductions, when compared with the commercial glanded Acala SJ-2. If the present lines of glandless cotton are to be grown commercially, we suggest they be produced in geographical areas essentially free from cotton pests.

We are now investigating the potential of breeding these glandless cottons for reduced susceptibility to lygus bugs and bollworms. This is being attempted by identifying resistant characters in wild cottons, then breeding those characters into agronomic glandless stock, thus raising insect resistance to a level comparable to that of commercial glanded cotton.

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TABLE 1. GROWTH, SURVIVAL, AND EMERGENCE OF *Lygus hesperus* NYMPHS ON LINES OF ISOGENIC GLANDED AND GLANDLESS ACALA COTTON

Genotype	Growth rate	Survival†
	mg per day	*percent*
SJ-1 glandless	0.52*	100*
SJ-1 glanded	.35	50
4-42-77 glandless	.28*	91*
4-42-77 glanded	.15	59

* Significantly greater than the isogenic glanded cotton at the p=0.05 level based on student's t-test.

† Survival recorded after seven days of confinement on the test cotton.

TABLE 2. MEAN NUMBERS OF *Lygus hesperus* IN NO-CHOICE FIELD CAGES OF ISOGENIC SJ-1 GLANDED AND GLANDLESS COTTON AFTER FIVE WEEKS OF INFESTATION AT SHAFTER, CALIFORNIA, 1973

		Adults		
Genotype	Nymphs	Females	Males	Total
SJ-1 glandless	53*	157*	159*	371*
SJ-1 glanded	12	62	74	149

* Significantly greater than the isogenic glanded cotton at the p=0.05 level based on student's t-test.

TABLE 3. SEASON TOTAL NUMBERS* OF INSECTS AND SPIDERS FROM FIELD PLOTS OF GLANDED AND GLANDLESS COTTONS. USDA COTTON RESEARCH STATION, SHAFTER, CALIFORNIA, 1975

	Total mean number individuals per 20 samples of each genotype						
	Pests		Predators				
Genotype	*Lygus hesperus*	*Empoasca* spp.	Pirate bugs (*Orius tristicolor*)	Bigeyed bugs (*Geocoris* spp.)	Damsel bugs (*Nabis* spp.)	Spiders	Total predators
Acala SJ-1 glanded	69 a†	369 a	303	695	13	109	1,120
Acala SJ-1 glandless	125 b	261 b	348	744	14	101	1,207
Acala 4-42-77 glanded	88 a	409 a	294	749	10	76	1,129
Acala 4-42-77 glandless	130 b	268 b	361	808	29	104	1,302

* Each arthropod category is represented by a total of 20 D-vac samples of 25 sucks each. One sample was collected in each of four replicates for a single cotton genotype on June 20 and 30, July 9, 18, and 24.

† Totals followed by the same letter are not significantly different at the p=.10 level using analysis of variance and the LSD method.

TABLE 4. YIELDS AND LYGUS DAMAGE OF GLANDLESS AND GLANDED ACALA IN 7- TO 12-ACRE PLOTS AT FOUR LOCATIONS, SAN JOAQUIN VALLEY, CALIFORNIA, 1975

	Acala lint yield			
Location	Glanded SJ-2	Glandless G8160	G8160 as % of SJ-2	Lygus damage per location*
	pounds per acre		%	
Corcoran	1,152	1,128	98	None
Visalia	1,294	1,322	102	Light, sporadic; late season
Bakersfield	1,230	1,099	89	Light, chronic; mid- to late season
Five Points	1,588	1,321†	83	Light, chronic; mid- to late season
Mean	1,316	1,217	92	

Note: The authors gratefully acknowledge the assistance of John Dobbs and Merrill Lehman in collecting yield data.

* Visual ratings of G8160 plots taken by T. F. Leigh. Damage was rated on a scale of light, medium or heavy. "Chronic" refers to damage done continuously throughout one or more seasonal divisions (e.g., chronic, mid- to late season) whereas "sporadic" refers to damage done intermittently.

† The yield of glandless G8160 was statistically less than the glanded Acala SJ-2 at the p=.12 level using student's t-test.