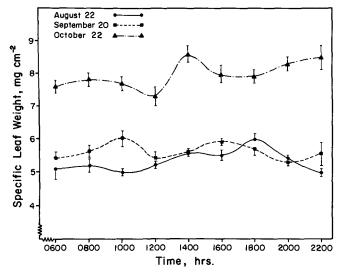Fig. 3. Diurnal changes in specific leaf weight of sugarbeet leaves at three periods during the growing season. Vertical bars represent standard errors of the mean.

the later portion of the growing season (Cole, unpublished data). This increase in photosynthetic products diverted to the storage region may be related to less total leaf expansion and the slower growth rates of the leaves initiated during the latter portion of the growing season.

Specific leaf weight changes rapidly as the leaves develop and increase in size (Fig. 2). During August and early September, the SLW was high as the leaves unfolded, decreased as the leaves expanded, and increased as the leaves matured. Leaves developing in late September and October had a higher SLW than leaves developing earlier in the season. Diurnal changes in SLW were evident on each sampling date (Fig. 3). Changes in SLW during the day may be related to changes in translocation rates of photosynthetic products.

The data reported indicate the importance of selecting leaves of uniform age in measuring photosynthesis and other physiological parameters of sugarbeet leaves. Additional experiments are needed to evaluate if the reduction in leaf growth rates is related to an increase in sucrose content of the roots.

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PERSISTENCE OF THE GLANDLESS GENOTYPE IN A COMPOSITE CROSS OF UPLAND COTTON ON THE TEXAS HIGH PLAINS[1]

J. E. Quisenberry, L. L. Ray, and D. R. Rummel[2]

ABSTRACT

A composite-cross population, grown for 10 generations, was used to evaluate the amount of natural selection on the glandless genotype of Upland cotton (Gossypium hirsutum L.). The results suggested that the glandless genotypes was not at a selective disadvantage when compared with the glanded genotype on the Texas High Plains.

Additional index words: Gossypium hirsutum L., Natural selection, Insect resistance.

COTTON (Gossypium hirsutum L.) produces more than fiber. With each 100 kg of fiber, the cotton plant yields approximately 170 kg of cottonseed, of which 95% is available for processing. Such products as cooking oil, linters, and cottonseed meal and hulls (for livestock feeding) have long been familiar to the public (2). The protein in cottonseed meal has been generally restricted to ruminant animals because of the presence of gossypol, a phenolic substance toxic to nonruminant animals.

For some years, extensive research has been conducted to evaluate the use of cottonseed as a source of protein for monogastric animals. Studies have been conducted to calculate the tolerance level of various animals for gossypol and a process has been developed for its removal (2). However, gossypol still imposes problems in the processing of cottonseed oil and meal because of reduced efficiency and increased cost associated with this removal process.

Glandless, gossypol-free, cultivars have been developed by cotton geneticists and breeders (3, 6). These glandless cottons increase the potential availability of cottonseed protein for human consumption. However, since the gossypol contained in the pigment glands appears to provide cotton with some degree of insect resistance (1, 10), glandless cultivars could be at a selective disadvantage under the conditions of heavy insect populations (10). Some studies have shown that certain insects that do not normally attack cotton damage the glandless cultivars (1, 4, 5, 8, 9). Therefore, glandless cotton production on a commercial basis may be best suited to areas with the least insect pest hazards.

Historically, the Texas High Plains has experienced few major cotton insect problems. Consequently, producers in the area use relatively little insecticide. For example, in 1969, the average cotton producer across the U. S. Cotton Belt spent $7.61/ha on insect control. Whereas, the High Plains producer only spent $0.59/ha (9). The purpose of this research was to evaluate the degree of natural selection pressure exerted on the glandless genotype when it was grown in an environment that is relatively free of cotton insects, the Texas High Plains.

Table 1. Observed and expected percentage of glandless plants in F_2 through F_{11} generations.

Year grown	Generation	No. of plants			Glandless plants		Chi-square	P*
		Glanded	Glandless	Total	Observed	Expected		
					%			
1960	F_2	525	18	543	3.31	2.50	1.48	0.20–0.30
1961	F_3	581	40	621	6.44	5.63	0.77	0.30–0.50
1962	F_4	631	53	684	7.74	7.66	0.01	0.90–0.95
1963	F_5	543	46	589	7.80	8.79	0.71	0.30–0.50
1964	F_6	482	48	530	9.06	9.39	0.07	0.70–0.80
1965	F_7	633	47	680	6.91	9.69	6.00	0.01–0.02
1966	F_8	504	36	540	6.66	9.85	6.16	0.01–0.02
1967	F_9	468	36	504	7.14	9.92	4.35	0.01–0.05
1968	F_{10}	489	45	534	8.42	9.96	1.40	0.20–0.30
1969	F_{11}	577	61	638	9.56	9.98	0.13	0.70–0.80

* P is the probability that the difference between the observed and expected values could have arisen due to chance or by sampling variation.

MATERIALS AND METHODS

The glandless genotype in cotton is conditioned by two recessive genes, gl_2 and gl_3 (6). These genes cause the cotyledons, leaves, stems, petioles, seeds, and carpel walls of the cotton plant to be free of the dark-colored spherical structures called "glands." A principal constituent of these glands is gossypol.

In 1959, all possible crosses, exclusive of reciprocals, were made among one glandless (gl_2gl_2, gl_3gl_3) and four glanded (Gl_2Gl_2, Gl_3Gl_3) strains of Upland cotton. In all, there were 10 F_1 hybrid combinations. These hybrids were self-pollinated in the Cotton Winter Increase Nursery at Iguala, Mexico, and approximately equal increments of F_2 seed from each hybrid were bulked to form a composite-cross population in 1960. This composite-cross population was grown in the cotton genetics nursery without selection for 10 generations (1960 to 1969) at Lubbock, Texas. The plot size varied among generations, but they were always 4 to 6 rows wide and 122 to 213 m long with 1 m between rows. The entire plot was harvested, and a random sample of seed was saved from each generation and stored in a cold room to reduce seed deterioration. During these years, the material was not artificially self-pollinated, and chemical insecticides were not applied.

In 1973, seed from each generation (F_2 to F_{11}) were germinated in sandperlite culture in the greenhouse. Each seedling that emereged was scored as either glanded or glandless by the presence or absence of glands on the cotyledons and hypocotyl (7). The percentage of glandless plants in each generation was determined and compared with the percentage of glandless plants that would he expected from complete self-pollination with no gametic or embryonic selection. The following formula was used to calculate the expected percentage of glandless plants.

$$\% \text{ glandless plants} = \frac{a[(\frac{2m-1}{2m})^n]}{bc} \times 100$$

where a = the number of heterozygous F_1 hybrids,
b = the number of pure breeding genotypes expected with self-fertilization,
c = the total number of F_1 hybrids used in the original composite population,
m = the generation of self-fertilization, and
n = the number of heterozygous gene pairs.

Chi-square analyses were used to determine if the observed deviated significantly from the expected percentage of glandless plants. Since cotton is not completely self-pollinated, and the amount of self-pollination varies with the amount of pollinator insect activity, significantly deviations could result from either (i) a large amount of natural outcrossing or (ii) a selective disadvantage of the glandless genotype. Although no self-pollination records were kept for this material, checks in other locations and in earlier years have shown the amount of natural outcrossing at Lubbock, Tex., to be generally less than 5%.

RESULTS AND DISCUSSION

The glandless genotype did not appear to be at a selective disadvantage when compared with the glanded genotype (Table 1). Chi-square analyses showed that the observed percentage of glandless plants did not significantly deviate from the expected values in 7 of the 10 generations. In the F_7, F_8, and F_9 genera-

tions, the observed percentage of glandless plants did significantly deviate from the expected values; however, the expected percentage of glandless plants was reestablished in the F_{10} and F_{11} generations. This return to the expected percentage of glandless plants suggests that the deviations were probably due to outcrossing within the composite-cross population and not a result of natural selection against the glandless genotype. These results indicate that environmental pressure (insects, disease, drought, etc.) exerted on the glandless genotype was no greater than that exerted on the glanded genotype. If damaging cotton insects had shown a preference for the glandless genotype, it would have been at a selective disadvantage and its genotypic frequency would have been expected to decrease.

The hectares of glandless cotton on the High Plains of Texas is expected to increase substantially in the future, and the results we have obtained may not be indicative of the insect situation that might develop if a large number of hectares of glandless cotton were grown. Therefore, additional research of insect monitoring on large scale plots must be conducted to determine the insect population dynamics that could develop when extensive plantings of glandless cultivars are made.

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