A STUDY OF THE INHERITANCE OF THE PIGMENT GLANDS IN UPLAND COTTON

By

DOUGLAS FARRAR OWEN

Bachelor of Science

Texas Technological College

Lubbock, Texas

1951

Submitted to the faculty of the Graduate School of
Oklahoma State University in partial fulfillment
of the requirements for the degree of
MASTER OF SCIENCE
May, 1961

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OF THE PIGMENT GLANDS

IN UPLAND COTTON

Thesis Approved:

James S Brooks
Thesis Adviser

Jay C Murray

Louis Madison
Dean of the Graduate School

ACKNOWLEDGEMENTS

The author wishes to express his sincere appreciation to Dr. Jay C. Murray for his guidance and encouragement throughout the course of this study and for his constructive criticism in the preparation of the thesis. The author would also like to thank the members of the advisory committee, Dr. Charles L. Leinweber, Dr. James S. Brooks, Dr. Robert Reed, and Dr. Glen W. Todd for their valuable assistance.

Grateful acknowledgement is extended to the Agronomy Department of Oklahoma State University for the use of its facilities and to Dr. Marlowe D. Thorne and the Oklahoma State Experiment Station for the Research Assistantship without which the author could not have pursued his study.

Gratitude is expressed to Ed Oswalt, Jerome Simmons, Margaret Simmons, E. F. Young, Robert Bridge, Brooks Bell, and Herman Waters for their able assistance in this study.

Appreciation is expressed also to the author's parents for instilling in the author the desire for learning and for the knowledge of the value of an education.

To the author's wife for her help in the typing of the thesis, but moreover for her untiring devotion, patience, encouragement, faith and inspiration, the author is grateful.

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INTRODUCTION

Toxicity of cottonseed is caused by the presence of free gossypol, which is a phenolic compound found in the pigment glands of the cotton plant.

The cottonseed industry has made important advances in seeking methods to remove gossypol from its products. However, only recently have the problems been attacked at their source, namely the pigment glands of the plant.

Through the research of various chemists, the idea of removing or reducing the number of these glands by plant breeding evolved. Information now available indicates that the plant breeder may be able to completely eliminate the pigment glands and gossypol from the plant. The removal of the glands and gossypol from the plant would result in reduced costs, increased profits, increased quality of products, and new markets.

The purpose of this study is to try to determine the inheritance of certain glandless characteristics of a single plant selection and to determine the possibility of incorporating this desired attribute into several commercial varieties.

LITERATURE REVIEW

Although much research has been done on the chemical and physical nature of gossypol and the pigment glands in which gossypol is concentrated, relatively little research has been done on the genetic inheritance of these glands. That these pigment glands (sometimes referred to as oil glands) have been noted in cotton for many years is evidenced by the fact that their presence is an important taxonomic character used in the classification of cotton and related species (Hutchinson, Silow and Stephens, 1947). As early as 1912, Lewton reported that a cotton grown by the Hopi Indians was found to have variable numbers of pigment glands in the boll. Fulton (1938) later found this Hopi cotton to breed true for several characters including what he referred to as "smooth and pitted" bolls. The pits were caused by oil or pigment glands.

In 1886 an English chemist isolated a yellow pigment from the "foots" obtained in alkali refining of expressed cottonseed oil. Several years later a Polish chemist, Marchlewski, purified the pigment from the same source and named it gossypol, from gossyp (ium phen) ol, to indicate both its origin in cottonseed and its chemical nature (Boatner, 1948). It was not until 1947 that Boatner et al. found that the gossypol in the cottonseed kernel was

located only in the pigment glands and that it comprised 30 to 50 per cent by weight of the glands.

The first recorded observation that pigment glands might be genetically controlled was made by Smirnova (Boatner, 1948). In her studies of the gossypol content in Gossypium, she analyzed seed from a large number of varieties of cotton grown in the Azerbaijan Republic (Transcaucasian) and from varieties grown the same year in the Uzbec Republic (Mid-Asiatic). She noted a positive correlation of gossypol content and the number of pigment glands. The number of glands in G. herbaceum (low gossypol content) was from one half to one third that of G. barbadense which contains three to four times as much gossypol as G. herbaceum. In both gland number and gossypol content, G. hirsutum was intermediate between G. herbaceum and G. barbadense. She concluded that genetic factors exerted considerable influence on the gossypol content of seed independently of environmental conditions. Goldovskii also concluded that the wide variation in gossypol content in different samples of cottonseed must be due to more than climatic or nutritional factors (Boatner, 1948).

Pons et al. (1953) indicated that climate also affects gossypol content. They found that gossypol in the kernels was negatively correlated with temperature and positively correlated with rainfall. They stated that individual varieties differed in their response to the environmental factors of temperature and rainfall. Rhyne

et al. (1959) found that with glandless-leaf lines, seasonal and environmental conditions influenced gossypol content only to a limited extent and that differences in gossypol content between lines were primarily genetic differences. However, in one experiment, they reported a significant line x environment interaction for gossypol content when a number of environmental variations were considered within a single year.

O'Kelly (1957), measured the gossypol content of open pollinated and inbred lines. He presented data which showed that high gossypol content was dominant in hybrids, gossypol content was higher in seed grown under irrigation, and open pollinated seed had a higher gossypol content than inbred seed of the same line. It might be concluded from O'Kelly's investigation that gossypol content, and presumably numbers of pigment glands, are affected by both environmental and genetic factors.

In 1954, McMichael reported a glandless boll condition of Gossypium hirsutum which was first noted in the F_2 of a cross between Acala 1517 and Acala 1-13-3. The glandless boll was completely recessive in the F_1 and segregated in the ratio of 3:1 in the F_2. McMichael (1954) proposed the symbol gl_1 for the glandless-boll mutation and suggested that the glandless-boll phenotype might serve as a marker ideally suited for measuring the amount of natural crossing in cotton. The gl_1 gene affects only the hypocotyl and boll, and does not have any effect on the number of pigments in the cotyledons. Therefore, there is no reduction in

gossypol content of the kernels in plants having $\underline{gl_1}$.

McMichael (1959) and Rhyne et al. (1959) independently reported that Hopi Moencopi, the cotton reported by Fulton (1938), was a source of additional genes for glandlessness. McMichael (1954) found that by selection in Hopi plants, the gland content of leaves and bolls could be reduced practically to zero, but the seeds were not materially affected. However, when Hopi Moencopi (Hopi M) was crossed to varieties or strains of Upland cotton, selections with glandless seed were found in later segregating generations. The total gossypol content of the seed from these glandless segregants was only 0.022 per cent and free gossypol content was only 0.006 per cent, as compared to 1.312 per cent for the glanded strains.

Rhyne et al. (1959) made crosses between Hopi M and an Acala selection carrying $\underline{gl_1}$. They found, as did McMichael (1959), that in the F_2 and F_3 generations of this cross, there was significantly less gossypol in the kernels of the glandless segregants. In addition, their data showed that the alteration of the number and size of the pigment glands in the leaves at the flowering nodes concomitantly indicated an alteration of the gossypol content of the seed. By using this glandless leaf index, they were able to select non-segregating progenies with less than 0.55 per cent gossypol content. In 1960, McMichael reported data from which he concluded that two other genes, $\underline{gl_2}$ and $\underline{gl_3}$, working together

produce a completely glandless cotton plant. By selecting for a reduced number of glands in a cross of Hopi Moencopi and Acala, McMichael isolated plants that were essentially glandless. These plants had glandless cotyledons and leaves in addition to glandless stems, petioles and bolls. Thus, the gossypol content of these glandless strains was reduced to nearly zero. McMichael selected a completely glandless strain from this Hopi M x Acala cross and designated it as 23B. The 23B strain was then crossed with various normally glanded stocks, assumed to be $\underline{Gl_2}\underline{Gl_2}\underline{Gl_3}\underline{Gl_3}$ genotype. The F_2 and backcross progenies to both glandless and glanded parents were produced. Segregation in these F_2 and backcross generations supported the hypothesis that the difference between glanded and glandless strains of cotton is controlled by two gene pairs. McMichael also included in this study a cross between a normally glanded stock and a glandless strain carrying $\underline{gl_1}$ as well as $\underline{gl_2}$ and $\underline{gl_3}$. The results of this cross showed that $\underline{gl_1}$ did not affect the action of $\underline{gl_2}$ and $\underline{gl_3}$. McMichael concluded that $\underline{gl_2}$ and $\underline{gl_3}$ masked the expression of the $\underline{gl_1}$ gene, and that further work was necessary "to clarify the role of other genes, alleles, and modifiers" that might be associated with the expression of glandlessness in cotton.

From more recent work, McMichael (unpublished) reported at the 1960 Regional S-1 meetings that he had grown progeny and worked out the phenotypic-genotypic relation-

ships shown in Table I.

TABLE I

GENOTYPE AS RELATED TO PHENOTYPE*

Genotype 1/	Cotyledon	Stem Axil	Stipule	Leaf	Boll	Pistil
$\underline{Gl_2}\underline{Gl_2}\underline{Gl_3}\underline{Gl_3}$	≠	≠	≠	≠	≠	≠	≠
$\underline{Gl_2}\underline{Gl_2}\underline{Gl_3}gl_3$	≠	≠	≠	≠	≠	VF	≠
$\underline{Gl_2}gl_2\underline{Gl_3}\underline{Gl_3}$	R	≠	≠	≠	F	-	≠
$\underline{Gl_2}gl_2\underline{Gl_3}gl_3$	R	≠	≠	≠	VF	-	≠
$\underline{Gl_2}\underline{Gl_2}gl_3gl_3$	R	R	≠	≠	VF	F	≠
$gl_2gl_2\underline{Gl_3}\underline{Gl_3}$	M	R	≠	≠	VF	-	≠
$\underline{Gl_2}gl_2gl_3gl_3$	M	-	≠	-	-	-	-
$gl_2gl_2\underline{Gl_3}gl_3$	M	-	≠	-	-	-	-
$gl_2gl_2gl_3gl_3$	-	-	-	-	-	-	-
gl_1gl_1	≠	-	-	≠	≠	-	≠

*≠ = glanded
R = reduced
M = outer margin
F = few
VF = very few
- = glandless

1/ McMichael's unpublished data

MATERIALS AND METHODS

The stock used as a parent (designated 6454) was selected from material derived from crosses between Rowden 41-B-100-2 and Stoneville 20B-5. The strain designated as 20-B-5 resulted from a plant with a reduced number of glands which McMichael 2/ selected from Stoneville 20 at Chickasha in 1956. McMichael reselected within the progeny of 20-B-5 and developed a completely glandless strain. The completely glandless stock 20-B-5 was used as the tester strain in this study. Any reference to the 20-B-5 strain in the subsequent discussion of the study refers to the completely glandless strain obtained from McMichael. The plant designated 6454 was selected from the progeny of the first backcross of the hybrid (Rowden 41-B-100-2 x Stoneville 20B-5) to Stoneville 20B-5 because it had fewer glands on the boll than did the other progeny members. In the following discussion, the term "reduced" will apply to a plant or a part of a plant having fewer pigment glands than a normally glanded cotton plant.

To explore the possibility of obtaining information concerning the evolutionary aspects of the "reduced"

2/ Geneticist, Crops Research Division, ARS, USDA, U.S. Cotton Field Station, Shafter, California.

boll phenotype, the following glanded stocks representing diverse pedigrees were selected for crossing purposes: Paymaster 54B, Acala 1517C, Stoneville 62, and Deltapine 15. The pedigrees of these varieties are shown in Figure 1. Presumably if G. hirsutum is in a process of becoming more diploidized, varieties of diverse origin might differ in the number of genes they carry that are actively functioning to produce glands.

In order to study possible linkage relationships between the gene producing the reduced gland phenotype and other markers, 6454 was also crossed to Texas 582 and Texas 586. Texas 586 carries the following dominant markers: glanded, red plant, naked seed, brown lint, petal spot, yellow pollen, okra leaf, pilose, yellow petal, non-virescent, non-frego bract, non-cup leaf, and non-cluster. Texas 582 carries the recessive genes for all the above markers. Since no lint or seed was produced in the F_2 generation, the brown lint and naked seed markers were not observed.

The "reduced" stock, 6454, was transplanted from the Perkins nursery to the greenhouse in Chickasha in September, 1959. In the fall of 1959, 6454 was crossed with the four commercial varieties of diverse pedigree as well as with the two marker stocks. The seed from these crosses were planted in the Perkins nursery on May 13, 1960. The resulting plants were evaluated and classified for degree of glandlessness, and then selfed

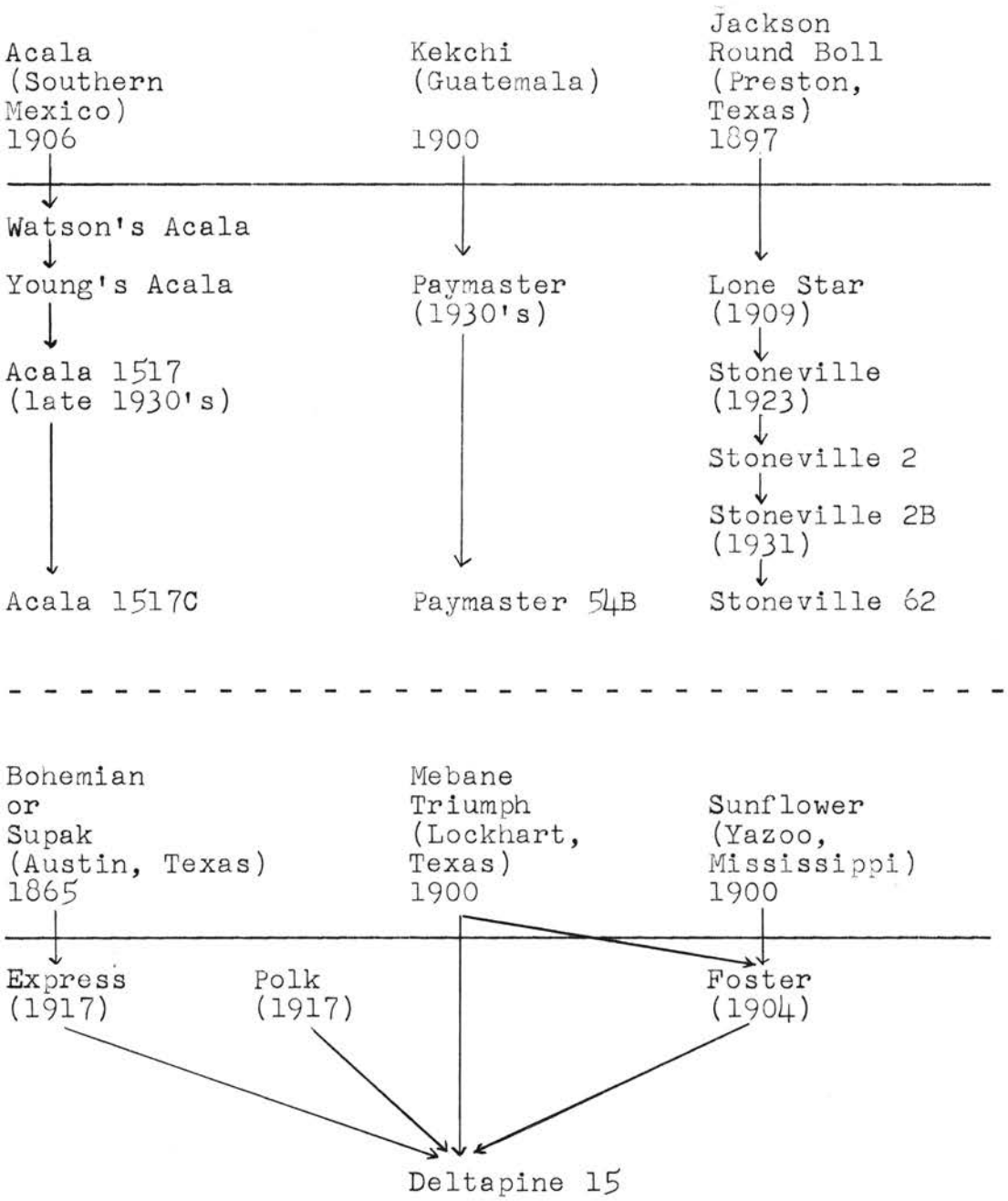

Figure 1. Pedigrees of the various glanded commercial varieties used as glanded parental types and crossed with reduced-glanded 6454.

and backcrossed to 6454. Test crosses between the Paymaster 54B x 6454 F_1 plants and McMichael's 20-B-5 were also made. The selfs, backcrosses, and test crosses were harvested as they matured in September, 1960. On October 1, 1960, the following backcrosses and test crosses were planted in the greenhouse at Chickasha:

(Texas 586 x 6454) x 6454
(Acala 1517C x 6454) x 6454
(Paymaster 54B x 6454) x 6454
(6454 x Stoneville 62) x 6454
(Paymaster 54B x 6454) x 20-B-5 (Test cross)
(Deltapine 15 x 6454) x 6454

Because of space limitations in the greenhouse, the individual backcrosses of each of these crosses were bulked and planted in a single row in the greenhouse.

In December, 1960, the cotyledons of the backcross F_2 progeny were classified for glandlessness; and on February 4, 1960, the mature plants were evaluated and classified. These plants were then removed from the greenhouse, and on February 6, 1961, F_2 seed of the following crosses were planted in their place:

(Texas 586 x 6454)
(Acala 1517C x 6454)
(Paymaster 54B x 6454)
(6454 x Stoneville 62)
(Texas 582 x 6454)
(Deltapine 15 x 6454)

These rows were thinned February 27, 1961, and a total of 2061 seedlings were removed and classified. The cotyledons of the plants remaining in the greenhouse were labelled and classified March 11, 1961.

The plants were classified on the basis of visual

observation of the degree of glandedness on the cotyledons, stems, axils, stipules, leaves, pistils, and bolls. The grades used in classifying the F_1 plants were as follows:

1 = no glands found on any of the parts of the plant listed above
2 = only a limited number of glands on the parts of the plant listed above
3 = reduced glands around the margin of the leaf with a few scattered over the other parts listed above.
4 = reduced but more than grade 3
5 = numerous glands over entire plant

The degree of glandedness on the mature bolls of plants placed in each of these classes is illustrated in Figure 2. The F_2 and backcross progenies grown in the greenhouse were classified as either glanded (/), reduced glandedness (R), or glandless (-), and the axils and stipules were classified as either glanded (/), or glandless (-). The cotyledons of the F_1 plants were not classified. Because of the difficulty in distinguishing grades 3 and 4, the cotyledons of the plants in the F_2 and backcross generations were classified as glanded (/), reduced glandedness (R), or marginal (M) (glanded around the margins only).

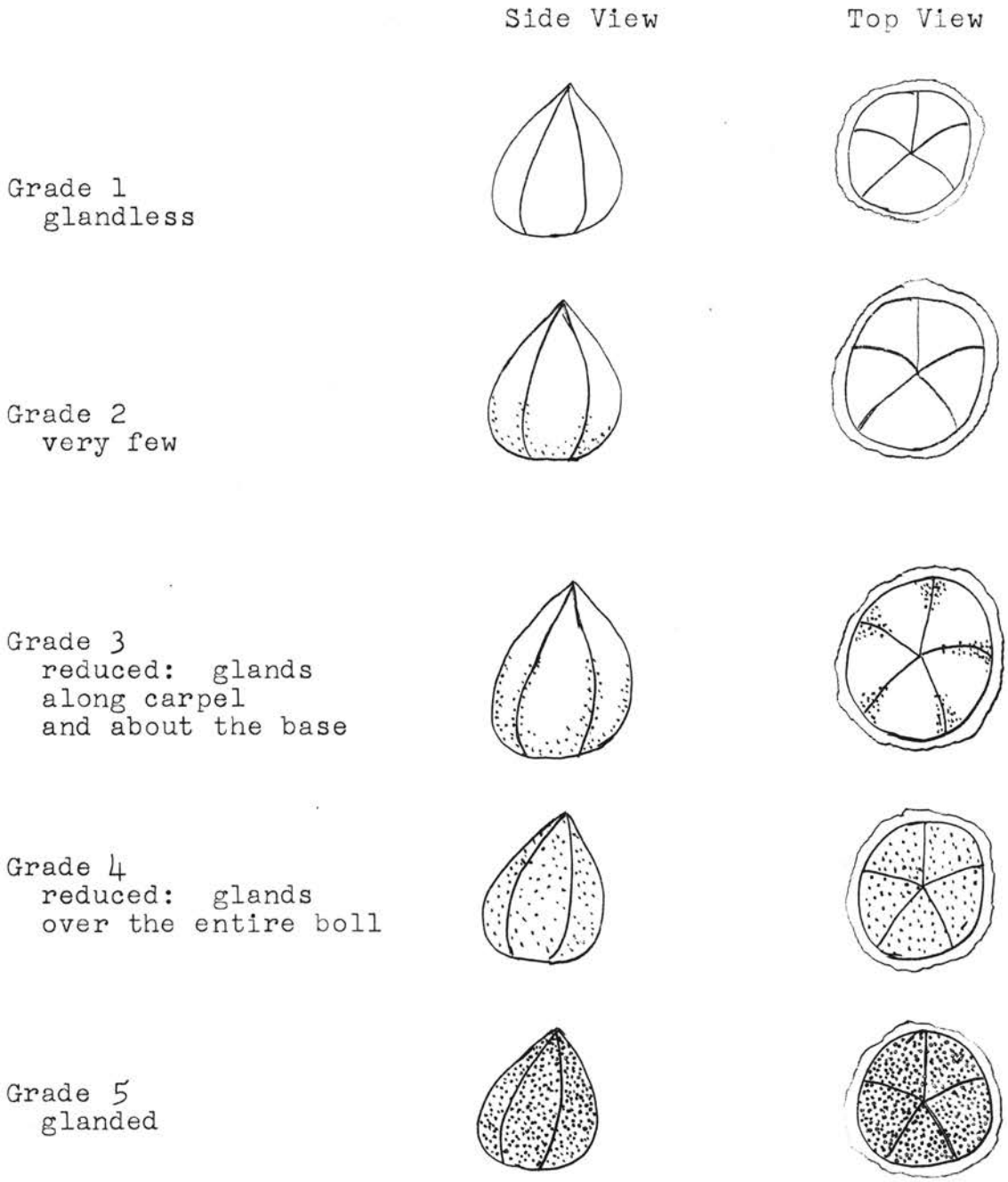

Figure 2. Grade Classification and Distribution of Pigment Glands on Bolls.

RESULTS AND DISCUSSION

Mature F_1 plants of the cross between the parent with reduced glands, 6454, and the normally glanded stocks have a glanded expression intermediate between the parents. The hybrids have considerably more glands than 6454, but noticeably fewer than the normally glanded parents. There is more than a little over-lap in the degree of glandedness in the F_1, making an accurate or positive classification difficult. The classification of the mature F_1 plants is shown in Table II.

TABLE II

CLASSIFICATION BY GRADE OF PARENTAL TYPES AND OF MATURE F_1 HYBRIDS (GLANDED x 6454)

Parental Types	Leaf	Stem	Ligule	Pistil	Bract	Boll**
6454	3*	3	3	3	1	3
Glanded Parents	5	5	5	5	5	5
F_1 Hybrids						
Stoneville 62	4	4	4	4	2	3
Deltapine 15	4	4	4	4	2	3
Paymaster 54B	3	4	4	4	2	4
Acala 1517C	4	4	4	4	2	4
Texas 582	3	4	4	4	2	4
Texas 586	4	4	4	4	4	4

* 1 = glandless
2 = very few
3 = reduced: glands around margin of leaf with a few scattered over the leaf and boll
4 = reduced: glands scattered over entire plant
5 = normal: heavily glanded

** See Figure 2 for distribution of glands on bolls.

The seedling of the F_2 and backcross generations were classified as to degree of glandedness. The numbers of F_2 seedlings falling into each class are recorded in Table III.

TABLE III

F_2 SEGREGATION OF SEEDLINGS OF SIX COTTON VARIETIES CROSSED WITH 6454

Variety with which 6454 was crossed	No. of Seedlings		3:1 Ratio	
	Reduced	Glanded	X^2	P
Texas 586	254	89	.1643	.50 - .75
Acala 1517C	427	140	.0288	.75 - .90
Paymaster 54B	414	123	1.2569	.25 - .50
Stoneville 62	175	57	.0229	.75 - .90
Texas 582	68	24	.0580	.25 - .50
Deltapine 15	471	143	.9576	.25 - .50
Pooled	1809	576	.9169	.25 - .50
Heterogeneity			1.5716	.90 - .95

None of the cotyledons was completely glandless. However, the F_2 plants of the cross between Texas 582 and 6454 segregated for glandless stem and hypocotyl because Texas 582 carries $\underline{gl}_1$. Since $\underline{gl}_1$ does not affect the cotyledons, Texas 582 could be graded like the other F_2 progenies. Some difficulty was experienced in distinguishing the glanded from those intermediate between glanded and reduced glanded, so the glanded and intermediate plants were grouped into a single class and referred to as glanded. The pooled chi-square calculated for the data presented in Table III indicated a good fit for a 3:1 ratio. The heterogeneity chi-

square indicated that all the samples could be considered as having been drawn from the same population.

As shown in Tables IV and V, the data obtained from the segregation of the backcross progeny fit a 1:1 ratio of glanded and reduced. The test cross of (Paymaster 54B x 6454) x 20-B-5 gave a 1:1 ratio of glandless and reduced glands in the mature leaves at the flowering nodes, but gave bolls which were completely glandless.

TABLE IV

SEGREGATION IN THE BACKCROSSES OF THE F_1 HYBRIDS TO 6454 AND FROM THE TESTCROSS (PAYMASTER 54B x 6454) x 20-B-5 ACCORDING TO PIGMENT GLAND DISTRIBUTION IN THE MATURE LEAVES AT THE FLOWERING NODES

Glanded variety parent of F_1	No. of Plants		1:1 Ratio	
	Glanded	Reduced	X^2	P
Texas 586	21	22	.0233	.75 - .90
Acala 1517C	20	12	2.0000	.10 - .25
Paymaster 54B	19	16	.2571	.50 - .75
Stoneville 62	17	14	.2903	.50 - .75
Deltapine 15	16	11	.9259	.25 - .50
Pooled	93	75	1.9286	.10 - .25
Heterogeneity			1.5680	.90 - .95
	Reduced	Glandless		
*(Paymaster 54B x 6454) x 20-B-5	19	21	.1000	.75

* Test cross

TABLE V

SEGREGATION IN THE BACKCROSSES OF THE F_1 HYBRIDS TO 6454 AND FROM THE TESTCROSS (PAYMASTER 54B x 6454) x 20-B-5 ACCORDING TO PIGMENT GLAND DISTRIBUTION IN THE MATURE BOLLS

Glanded variety parent of F_1	No. of Plants		1:1 Ratio	
	Glanded	Reduced	X^2	P
Texas 586	18	19	.0270	.75 - .90
Acala 1517C	21	11	3.1250	.05 - .10
Paymaster 54B	19	16	.2571	.50 - .75
Stoneville 62	16	14	.1332	.50 - .75
Deltapine 15	15	11	.6154	.25 - .50
Pooled	89	71	2.0250	.10 - .25
Heterogeneity			2.1327	.50 - .75
		Glandless		
*(Paymaster 54B x 6454) x 20-B-5	0	29		

*Test cross

In every case, the pooled chi-square values indicate a good fit for the various ratios and the heterogeneity chi-square is acceptable evidence that all samples could be considered as having been drawn from the same population. Therefore, it might be concluded that regardless of the wide diversity of the pedigrees of the glanded parents, the pigment glands are controlled by the same gene or genes in all of them.

Populations in this study were too small to obtain any reliable or conclusive evidence pertaining to linkage of glandless to any of the markers utilized. However, the data obtained seemed to indicate that there was no linkage.

Although the number of glanded and "reduced" segregants indicate that a single gene determines the differences in degree of glandedness between 6454 and the glanded stocks, the evidence presented indicates that the inheritance of the pigment glands might be more complex than a single gene. The progeny resulting from selfed seed of 6454 were not uniform in their degree of glandedness, and none of the progeny in the seedling stage was found to be either fully glanded or completely glandless. The segregation of the backcrosses (F_1 hybrids to 6454) were different from those of the test crosses between the F_1 hybrids and the glandless tester 20-B-5. For glands in the mature leaves at the flowering nodes, the backcrosses segregated for glanded and "reduced" whereas the 20-B-5 test crosses segregated for "reduced" and glandless. In the cotyledon stage, the backcrosses segregated 1:1 for "reduced" and glanded, whereas the test crosses segregated 1:1 for "reduced" and marginal, as shown in Table VI. These results suggest that 6454 might be homozygous recessive for one major gene governing gland production and that 20-B-5 carries at least one other gene that interacts with the gene carried by 6454 to further reduce the degree of glandedness. These data and interpretations are in agreement with McMichael (1960) and Lee (unpublished). McMichael found the completely glandless condition to be governed by two recessive genes, $\underline{gl}_2$ and $\underline{gl}_3$. He also reported that the different combinations and dosages of

the recessive alleles at the gl_2 and gl_3 loci produced different degrees of glandlessness and that some parts of the plant are more sensitive to certain combinations than are others (Table I).

TABLE VI

SEGREGATION OF THE PIGMENT GLANDS IN THE COTYLEDONS OF THE BACKCROSS PROGENY AND THE PROGENY OF A CROSS BETWEEN A GLANDED TYPE AND 6454 FOLLOWED BY A TEST CROSS WITH 20-B-5

	(Acala 1517C x 6454) x 6454	(Paymaster 54B x 6454) x 20-B-5
Cotyledons		
Reduced	151	75
Glanded	138	
Marginal		61
Stems		
Reduced	151	75
Glanded	138	
Glandless		61
1:1 Ratio		
X^2	0.5846	1.4412
P	.25 - .50	.10 - .25

According to the scheme developed by McMichael and presented in Table I, 6454 very closely resembles the phenotype proposed for either the $Gl_2Gl_2gl_3gl_3$ or $Gl_2Gl_2Gl_3gl_3$ genotypes, particularly in respect to the gland distribution on the bolls. The data presented here are sufficient to distinguish which genotype is carried by 6454. If the genotype of 6454 were $Gl_2Gl_2Gl_3gl_3$, the

results of a cross between a glanded type and 6454 followed by a test cross with a $\underline{gl_2}\underline{gl_2}\underline{gl_3}\underline{gl_3}$ strain should be a ratio of 2 reduced to 1 marginally glanded cotyledon as shown in Figure 3.

$\underline{Gl_2}\underline{Gl_2}\underline{Gl_3}\underline{gl_3}$	x	$\underline{Gl_2}\underline{Gl_2}\underline{Gl_3}\underline{Gl_3}$	P_1
$\underline{Gl_2}\underline{Gl_3}$ ≠ $\underline{Gl_2}\underline{gl_3}$		$\underline{Gl_2}\underline{Gl_3}$	gametes
$\underline{Gl_2}\underline{Gl_2}\underline{Gl_3}\underline{Gl_3}$	≠	$\underline{Gl_2}\underline{Gl_2}\underline{Gl_3}\underline{gl_3}$	F_1
$\underline{Gl_2}\underline{Gl_3}$		$\underline{Gl_2}\underline{Gl_3}$ ≠ $\underline{Gl_2}\underline{gl_3}$	gametes
	x		
	$\underline{gl_2}\underline{gl_3}$		test cross gamete
$\underline{Gl_2}\underline{gl_2}\underline{Gl_3}\underline{gl_3}$ (Reduced)	$\underline{Gl_2}\underline{gl_2}\underline{Gl_3}\underline{gl_3}$ (Reduced)	$\underline{Gl_2}\underline{gl_2}\underline{gl_3}\underline{gl_3}$ (marginal)	progeny

Figure 3. Diagram of a cross between $\underline{Gl_2}\underline{Gl_2}\underline{Gl_3}\underline{Gl_3}$ and $\underline{Gl_2}\underline{Gl_2}\underline{Gl_3}\underline{gl_3}$ and a test cross with the resulting F_1 hybrid.

On the other hand, if the genotype of 6454 were $\underline{Gl_2}\underline{Gl_2}\underline{gl_3}\underline{gl_3}$ a cross between a glanded type and 6454 followed by a test cross with the double recessive should result in a 1:1 ratio of reduced and marginally glanded cotyledons as shown in Figure 4. The segregation of the glands in the leaves and stems in the above cross followed by a test cross should result in a 1:1 ratio of "reduced" and glandless. The backcross to 6454 should result in a 1:1 ratio of glanded and "reduced" in the cotyledons, leaves, stems and bolls. The results reported in Tables IV and VI are in agreement with this interpretation.

$\underline{Gl_2}\underline{Gl_2}\underline{gl_3}\underline{gl_3}$	x	$\underline{Gl_2}\underline{Gl_2}\underline{Gl_3}\underline{Gl_3}$	P_1
$\underline{Gl_2}\underline{gl_3}$		$\underline{Gl_2}\underline{Gl_3}$	gametes
	$\underline{Gl_2}\underline{Gl_2}\underline{Gl_3}\underline{gl_3}$		F_1
$\underline{Gl_2}\underline{Gl_3}$ / $\underline{Gl_2}\underline{gl_3}$			gametes
x			
$\underline{gl_2}\underline{gl_3}$			test cross gamete
$\underline{Gl_2}\underline{gl_2}\underline{Gl_3}\underline{gl_3}$ (Reduced)		$\underline{Gl_2}\underline{gl_2}\underline{gl_3}\underline{gl_3}$ (Marginal)	progeny

Figure 4. Diagram of a cross between $\underline{Gl_2}\underline{Gl_2}\underline{Gl_3}\underline{Gl_3}$ and $\underline{Gl_2}\underline{Gl_2}\underline{gl_3}\underline{gl_3}$ and a test cross of the resulting F_1 hybrid.

From these results, the tentative conclusion can be drawn that 6454 has the genotype $\underline{Gl_2}\underline{Gl_2}\underline{gl_3}\underline{gl_3}$ and that the variability in the degree of glandedness among the selfed progenies of 6454 is the result of the segregation of modifiers as proposed by Lee. Obviously, 6454 would not be as desirable for breeding purposes as other available stocks, such as 20-B-5 which contain genes for the completely glandless phenotype.

Although, in most respects, these data agree with those of McMichael and Lee, they are not conclusive. Consequently, the progenies should be carried through more generations and evaluated for glandlessness before definite conclusions may be made regarding the action of the major genes and the presence of modifiers involved in the development of cotton free of pigment glands.

SUMMARY AND CONCLUSIONS

A study was made of the inheritance of the "reduced" phenotype of a selection of Stoneville 20-B, designated as 6454. The data presented support the hypothesis of McMichael (1960) that the difference between glanded and glandless phenotypes in Gossypium hirsutum is controlled by two gene pairs. Evidence is presented which indicates that the genotype of the "reduced" selection from Stoneville 20-B is $Gl_2Gl_2gl_3gl_3$.

No evidence was found to indicate any differences in the inheritance of the "reduced" phenotype when six different varieties of cotton having widely divergent origins were used in the crosses. The varieties used presumably carry the same number of active genes for glandedness.

There was no indication of linkage between the glandless genes carried by 6454 and thirteen other genetic markers included in the study. Because of small populations of the progenies, the lack of linkages could not be definitely established.

The backcross data show that breeding glandlessness into the commercial varieties presently being grown in Oklahoma is feasible. However, the reduced glanded parent utilized in this study would not be as practical as a plant having the $gl_2gl_2gl_3gl_3$ genotype.

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VITA

Douglas Farrar Owen

Candidate for the Degree of

Master of Science

Thesis: A STUDY OF THE INHERITANCE OF THE PIGMENT GLANDS IN UPLAND COTTON

Major Field: Agronomy (Field Crops)

Biographical:

Personal data: Born February 21, 1930 at Olton Texas, the son of Charles M. and Leila Ellen Owen.

Education: Attended elementary school at Olton, Texas, graduated from Olton High School in 1947, received a Bachelor of Science degree from Texas Technological College with a major in Agricultural Education, in 1951. Attended Graduate School at Oklahoma State University 1959 to 1961.

Professional experience: Born in rural community and worked on the farm through high school and college years. Employed by Western Cottonoil Co., Littlefield, Texas, 1951 - 1955. Entered U. S. Army in January, 1955, and served at the Army Intelligence Center, Counter Intelligence Corps, Fort Holabird, Baltimore, Maryland, until January, 1957. Employed as an agent for the National Farm Life Insurance Co., Fort Worth, Texas, 1957. Served as Assistant Agronomist for the High Plains Research Foundation, Halfway, Texas, 1957 - 1959. Employed as Graduate Research Assistant in the Agronomy Department, Oklahoma State University, 1959 - 1961.

Member of: Alpha Zeta and Sigma Xi.

Date of final examination: May, 1961.