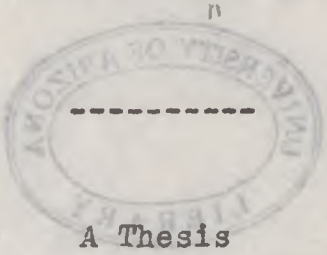
INHERITANCE OF BOLL SIZE IN COTTON

by

Harold J. Fulton



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INTRODUCTION

Professor W.E. Bryan of the Plant Breeding Department, College of Agriculture, University of Arizona, Tucson, Arizona is conducting a study of backcrossing in cotton breeding. In 1940 a portion of his material was turned over to the class in Advanced Plant Breeding which made a study of the inheritance of boll characters and of fiber characters. This paper reports on that part of the studies affecting boll size in cotton.

In a recent publication MacArthur[1] reports "that size genes determining fruit weight in the tomato act in a proportionate or geometric way." In a simple cross of Stoneville x Hopi the F_1 had an average seed cotton weight of 40.5 grams, while its parents averaged 50.0 g. and 18.6 g. respectively, the F_1 more nearly approaching the geometric average than the arithmetic average of its parents. As far as this limited test evidences, this same condition holds true in cotton but it does not explain the ratios of small, intermediate and large bolls as they are inherited in cotton.

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1. John W. MacArthur, "Size Inheritance in Tomato Fruits," Jour. Heredity, 32:9:291-295 (September, 1941).

MATERIALS AND METHODS

Two segregates of a complex cotton hybrid, whose geneology chart is shown in Figure 1, appear in the ancestry of the six progenies studied. These particular two plants were first grown in 1939 in a progeny of 30 F_1 plants. Boll size in this F_1 was distributed along a normal curve with plant No. 6, Figure 2, having small bolls and a rather small frame work, and Plant No. 3, Figure 3, had large bolls and was conconsiderably taller than No. 6. These plants have been "carried over" the winters in the greenhouse and were grown as perennials in 1939, 1940, and 1941. Each of these plants was selfed and each was crossed with Stoneville, a large boll type, Figure 4, and with Hopi, a cotton with small bolls, Figure 5. This selfed and crossed seed furnished the following six progenies grown in 1940:

(1) Progeny 235, or No. 3 selfed, 163 plants of which were used
(2) Progeny 243, or No. 3 x Stoneville F_1, 162 plants used
(3) Progeny 246, or No. 3 x Hopi F_1, 162 plants used
(4) Progeny 238, or No. 6 selfed, 47 plants used
(5) Progeny 249, or No. 6 x Stoneville F_1, 76 plants used
(6) Progeny 247, or No. 6 x Hopi F_1, 50 plants used.

In the fall of 1940, samples consisting of 10 bolls each were picked from each of these 658 plants, and the following characters were determined for each sample: (1) seed cotton weight; (2) lint weight; (3) lint per cent; (4) seed index; (5) number of seeds; (6) lint index; (7) seed fuzziness

GENEALOGY CHART

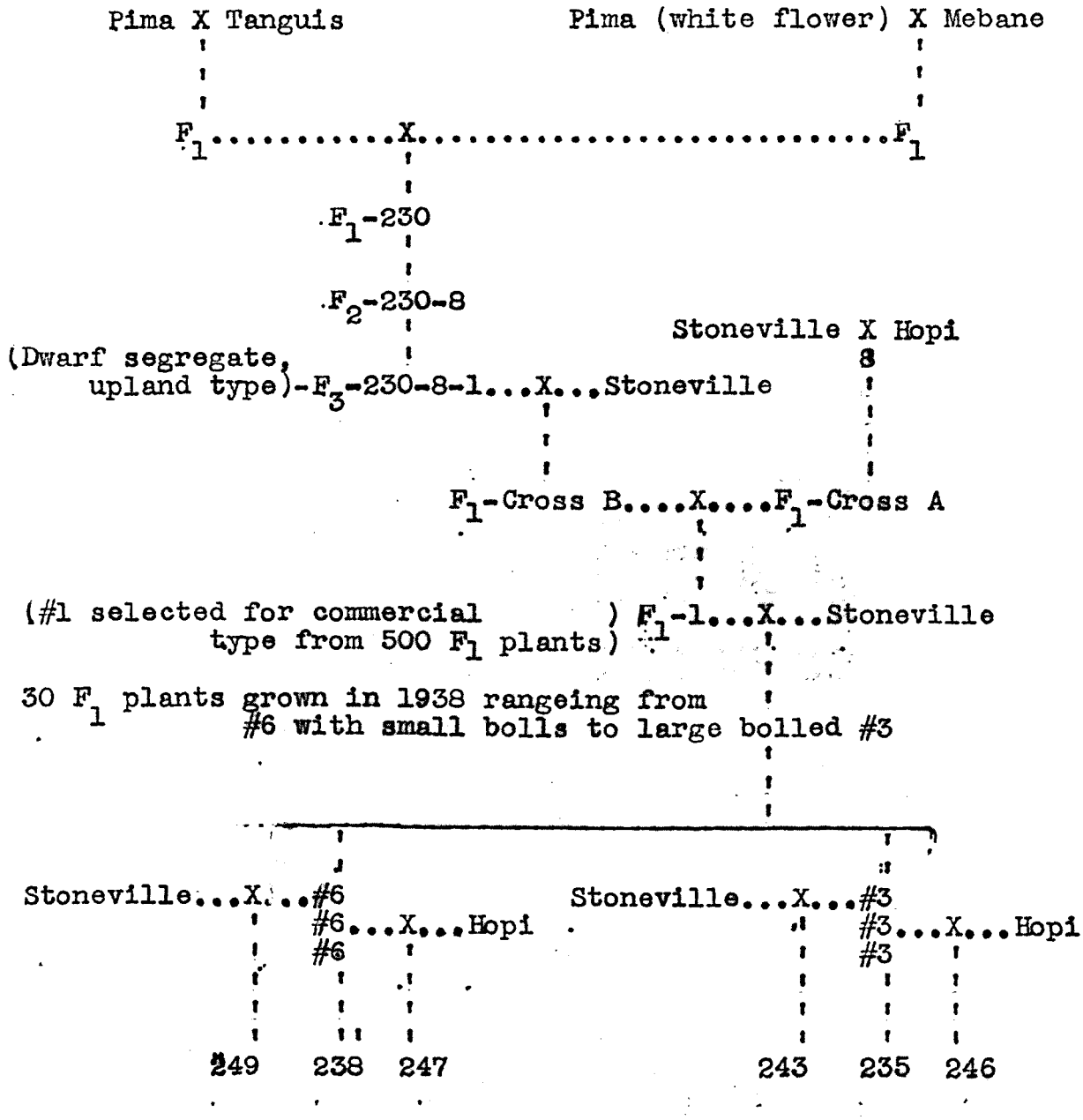

Fig. 1. Genealogy chart of cotton progenies designated as 235, 238, 243, 246, 247, and 249 in the 1940 breeding plots of the Plant Breeding Department, College of Agriculture, University of Arizona, Tucson, Arizona.

Fig. 2. Plant No. 6, the small bolled segregate used in the ancestry of Progenies 238, 247 and 249. Figs. 2, 3 and 5 are each enlarged to approximately 11/96 natural size so that direct comparison may be made of these three illustrations. (Photo by W.E. Bryan)

Fig. 3. Plant No. 3, the large bolled segregate used in the ancestry of Progenies 235, 243, and 246. Figs. 2, 3 and 5 are each enlarged to approximately 11/96 natural size so that direct comparison may be made of these three illustrations. (Photo by W.E. Bryan)

Fig. 4. Bolls of Stoneville cotton as grown near Tucson, Arizona in 1938

(Photo by W.E. Bryan)

Fig. 5. Plants of Hopi (small bolls) and of Stoneville (large bolls) cotton as grown near Tucson, Arizona in 1938. Figs. 2, 3 and 5 are each enlarged to approximately 11/96 natural size. (Photo by W.E. Bryan)

grade; (8) fiber length; (9) fiber fineness grade; and (10) fiber breaking strength. With the exception of seed fuzziness grade, the correlation coefficient for each of these characters with each of the others was determined. Those for the progenies of No. 3 selfed and the F_1's of its crosses with Stoneville and with Hopi are given in Table 1. Corresponding data for those of No. 6 are presented in Table 2.

Assuming that seed cotton weight is one of the best available measures of boll size, we find by reference to Tables 1 and 2 that this character is significantly correlated with (1) number of seeds per boll, (2) with seed index, (3) with lint index, and (4) with lint weight in all six progenies. Seed cotton weight is also significantly correlated with fiber length in progenies 235, 243, 246, and 247; but fiber length is not always correlated significantly with each of the other four characters named above. Seed cotton weight is also significantly correlated with lint per cent in progenies 235 and 246, and with fiber fineness grade in progeny 249.

These relationships indicated that five boll characters --those of (1) seed cotton weight, (2) lint weight, (3) seed index, (4) number of seeds, and (5) lint index--should be examined in any study of boll size inheritance. The means of these five characters for Plant No. 3, Plant No. 6, Stoneville, Stoneville x Hopi F_1, and for Hopi are given in Table 3. Table 4 gives data for the same characters of

Character	Progeny	Character: Seed Index	Lint Index	Lint Percent	Lint Weight	Fiber Length	Fiber Fineness Grade	Seed Cotton Weight
		r	r	r	r	r	r	r
Number of Seeds	235	-0.4874*	-0.2723*	+0.4781*	+0.5292*	+0.0327	-0.0554	+0.2845*
	243	-.2582*	-.0715	+.2711*	+.6181*	-.0148	+.6411*	+.5113*
	246	-.0685	-.0591	+.1715	+.7619*	+.2061	-.0445	+.7203*
Seed Index	235		+.7692*	-.6607*	+.3513*	+.5056*	+.0587	+.6768*
	243		+.7271*	-.5656*	+.8632*	+.4837*	+.1590	+.6463*
	246		+.5930*	-.9191*	+.3396*	+.4846*	+.1844	+.6382*
Lint Index	235			-.0470	+.7526*	+.2505*	+.1600	+.6091*
	243			+.6178*	+.7512*	+.2732*	+.7026*	+.6916*
	246			+.5232*	+.5539*	-.0389	-.1056	+.4218*
Lint Percent	235				+.2992*	-.7554*	+.0767	-.2174*
	243				+.4629*	-.3722*	+.9321*	-.1498
	246				+.3441*	-.9274*	+.2611*	-.2621*
Lint Weight	235					+.2232*	+.0993	+.9115*
	243					+.4880*	+.4065*	+.9196*
	246					+.1499	-.1435	+.8815*
Fiber Length	235						-.0396	+.5505*
	243						+.7971*	+.4000*
	246						-.0859	+.4409*
Fiber Fineness Grade	235							+.0663
	243							+.0442
	246							-.1827

* With populations of 160 or more plants in each progeny an r of ±.208 is required for significance with odds of 99:1

Table 1. Correlation of boll and fiber characters studied in the progenies of a complex cotton hybrid and it crosses; Progeny 235 being decendents of "Plant 3" selfed; Progeny 243, "Plant 3" x Stoneville F_1; and Progeny 246 is "Plant 3" x Hopi F_1.

Character	Progeny	Character: Seed Index r	Lint Index r	Lint Percent r	Lint Weight r	Fiber Length r	Fiber Fineness Grade r	Seed Cotton Weight r
Number of Seeds	238	±0.0505	-0.2704	±0.2131	±0.8277*	-0.0644	±0.1229	±0.8835*
	249	±.2745	-.0095	-.2754	±.6325*	-.6460*	±.2667	±.8616*
	247	±.4495	±.2772	-.0122	±.8768*	±.3212	-.0476	±.9359*
Seed Index	238		±.4490*	-.4613*	±.2621	±.1823	-.0789	±.5168*
	249		±.7152*	-.0612	±.5879*	±.4422*	±.3512*	±.7176*
	247		±.4674*	-.2024	±.5716*	±.4514*	-.0454	±.6971*
Lint Index	238			±.5761*	±.7417*	-.0636	±.2809	±.5710*
	249			±.5681*	±.5841*	±.2742	±.4470*	±.4971*
	247			±.7643*	±.7031*	±.3332	±.0869	±.4955*
Lint Percent	238				±.4950*	-.2000	±.3457	±.1001
	249				±.2059	±.1189	±.1963	-.1430
	247				±.3692*	±.0354	±.1562	±.0065
Lint Weight	238					-.1132	±.2523	±.8985*
	249					±.2216	±.4745*	±.7854*
	247					±.4107*	±.0082	±.9419*
Fiber Length	238						-.2661	-.0135
	249						±.1355	±.2219
	247						-.1344	±.4166*
Fiber Fineness Grade	238							±.1316
	249							±.3577*
	247							-.0521

*With a population of 76 plants Progeny 249 requires an r of ±.302 for significance with odds of 99:1
With populations of 47 and 50 plants each Progenies 238 and 247 require an r of ±.354 for significance with odds of 99:1

Table 2. Correlation of boll and fiber characters studied in the progenies of a complex cotton hybrid and its crosses: Progeny 238 being decedents of "Plant 6" selfed; Progeny 249, "Plant 6" x Stoneville F_1; and Progeny 247 is "Plant 6" x Hopi F_1.

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Table 3. Means of five boll characters of Plant No. 3, of Stoneville, of Stoneville x Hopi F_1, of Hopi, and of Plant No. 6

	Character				
	Seed Cotton Weight	Lint Weight	Seed Index	Number of Seeds	Lint Index
Progeny or plant	g.	g.	g.		g.
Plant No. 3	90.4	23.8	15.7	348	6.8
Stoneville	79.0	26.8	13.4	373	7.2
Stoneville x Hopi F_1	40.5	10.5	11.7	247	4.3
Hopi	23.2	3.6	10.2	182	2.0
Plant No. 6	34.5	10.0	9.8	240	4.2

Table 4. Means of five boll characters of progenies of Plat No. 3 selfed, of No. 3 x Stoneville F_1, of No. 3 x Hopi F_1, of Plat No. 6 selfed, of No. 6 x Stoneville F_1, and of No. 6 x Hopi F_1.

		Character				
		Seed Cotton Weight	Lint Weight	Seed Index	Number of Seeds	Lint Index
Progeny	N	g.	g.	g.	m	g.
235 or No. 3 selfed	163	71.78±.602	20.25±.164	15.77±.155	319.6±2.16	6.35±.049
243 or No. 3 x Stoneville	162	76.60±.592	23.96±.186	14.09±.106	364.7±~~2.06~~ 2.06	6.61±.042
246 or No. 3 x Hopi	160	37.60±.314	9.22±.076	12.63±.083	218.9±~~1.48~~ 1.48	4.22±.023
238 or No. 6 selfed	47	34.30±.956	10.22±.326	9.65±.158	240.6±5.52	4.24±.075
249 or No 6 x Stoneville	76	53.97±.831	17.60±.963	11.22±.111	312.5±3.63	5.63±.068
247 or No. 6 x Hopi	50	25.15±.644	5.95±.171	10.74±.101	173.0±3.67	3.42±.650

Progenies 235, 243, 246, 238, 249, and 247. It will be noted that in seed cotton weight, number of seeds, lint weight, and lint index a cross with Stoneville gave increased values and that a cross with Hopi gave decreased values, irrespective of whether No. 3 or No. 6 was the other parent used in making the cross. However, in the character of lint index, the increases resulting from crossing with Stoneville were small in proportion when compared with the increases in the other three of these four characters.

Seed index was the interesting exception in this group of five characters. Progeny 243, the F_1 of No. 3 x Stoneville, had a mean seed index 1.68 grams lower than the selfed progeny of No. 3. Progeny 249, the F_1 of No. 6 x Stoneville, had a mean seed index of 1.57 grams greater than the selfed progeny of No. 6. When Hopi was crossed with these plants, the mean seed index of Progeny 246, the F_1 of No. 3 x Hopi, is 3.14 grams smaller than the means of the selfed progeny of No. 3; while Progeny 247, the F_1 of No. 6 x Hopi, shows an increase in its average seed index of 1.09 grams over that of the selfed progeny of No. 6. In seed index, then, crossing either No. 3 or No. 6 with Hopi moved the means in the same direction as did crosses with Stoneville.

Table 5 a, b, c, d, e and f gives the frequency tables for these five characters. Each one has a mid-point rather easy to discern which divides them into groups that could be labeled small and large. The line comes between classes 45

Table 5. Frequency distributions in five boll characters of progenies 235, or No. 3 selfed; 243, or No 3 x Stoneville 246, or No. 3 x Hopi; 238, or No. 6 selfed; 249, or No. 6 x Stoneville; and 247, or No. 6 x Hopi.

a. Seed Cotton Weight

Progeny	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95
235					1	-	-	1	6	17	48	25	43	18	3	1	
243									1	5	19	43	36	39	14	3	1
246		1	3	32	81	40	3										
238	1	4	5	13	16	7	1										
249			1	2	1	3	5	29	21	11	3						
247	9	11	24	5	1												

b. Lint Weight

Progeny	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
235				1	-	-	2	16	50	65	25	4			
243								1	3	18	57	52	25	4	1
246			3	59	94	4									
238		2	5	14	15	9	2								
249			1	-	2	4	4	29	27	8	1				
247	1	22	25	2											

c. Seed Index

Progeny	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15	15.5	16	16.5	17	17.5	18	18.5	19	19.5	20
235								1	2	5	7	8	10	11	12	15	16	7	19	13	6	16	7	2	2	1
243								1	3	14	20	23	14	20	17	18	15	8	6	3						
246							3	25	23	21	21	31	19	12	3	2										
238	2	6	5	8	5	8	4	8	1																	
249		1	1	1	5	8	8	19	21	6	4	2														
247				1	7	9	13	10	8	2																

d. Number of Seeds

Progeny	100	120	140	160	180	200	220	240	260	280	300	320	340	360	380	400	420
235				1	-	-	-	2	3	22	50	48	26	7	1	1	
243											2	16	45	61	28	7	2
246		1	-	3	19	55	62	20									
238		1	1	-	6	3	12	9	7	8							
249						1	1	2	6	17	13	22	9	5			
247	1	4	10	13	14	7	1										

e. Lint Index

Progeny	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5
235							10	38	41	39	29	6
243							3	14	55	47	33	10
246				35	85	39	1					
238		1	1	9	20	12	4					
249				1	-	8	20	27	13	6	1	
247		3	22	22	3							

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and 50 in seed cotton weight, between 12 and 14 in lint weight, between 11.5 and 12.0 in seed index, between 240 and 260 in number of seeds, and between 4.5 and 5.0 in lint index. Table 6 summarizes this grouping into large and small classes, and gives the value of X^2 for departure from expected classes. The assumptions used in calculating the expectancies are that Plant No. 3 and Stoneville are homozygous for factors for large characters, and that Plant No. 6 and Hopi carried honozygous factors for small characters; that Hopi's small factors were dominant to No. 3's large factors, and that Stoneville's large factors were dominant to No. 6's small factors. However, Progeny 249 in all five characters showed that Stoneville's large factors were not completely dominant to No. 6's small factors; in fact, in seed index, small predominated in this progeny. Progeny 238, No. 6 selfed, gave significant departures from the expected in number of seeds, in lint index, and in lint weight. Progeny 247, No. 6 x Hopi, gave all five characters with small classifications with the exception of two plants which had large seeds. Progeny of Plant No. 3 and of those of its crosses with Stoneville and with Hopi did not have significant departures from the expected large-small classifications in seed cotton weight, in lint weight, or in lint index. All three progenies gave significant departures from the expected in seed index, and Progeny 235 had 3 plants with a small number of seeds per boll.

Table 6. Observed and expected frequencies in each of five characters when summarized into small and large groups for progenies 235, or No. 3 selfed; 243, or No. 3 x Stoneville F_1; 246, or No. 3 x Hopi F_1; 238, or No. 6 selfed; 249, or No. 6 x Stoneville F_1; and for 247, or No. 6 x Hopi F_1.

	Seed Cotton Weight				Lint Weight				Seed Index				Number of Seeds				Lint Index			
	Small	Large	X^2	P	Small	Large	X^2	P	Small	Large	X^2	P	Small	Large	X^2	P	Small	Large	X^2	P
Progeny																				
235 Obs.	1	162	1.006	.30	1	162	1.006	.30	3	160	9.005	o0	3	160	9.005	o0	0	163	-	-
235 Exp.	0	163			0	163			0	163			0	163			0	163		
243 Obs.	0	162	-	-	0	162	-	-	4	158	16.099	o0	0	162	-	-	0	162	-	-
243 Exp.	0	162			0	162			0	162			0	162			0	162		
246 Obs.	160	0	-	-	160	0	-	-	51	109	11,955.25	o0	160	0	-	-	159	1	1.006	.30
246 Exp.	160	0			160	0			160	0			160	0			160	0		
238 Obs.	47	0	-	-	45	2	4.085	.05-.02	47	0	-	-	32	15	229.79	60	43	4	16.340	8
238 Exp.	47	0			47	0			47	0			47	0			47	0		
249 Obs.	12	64	145.89	0	7	69	49,645	0	64	12	4149.895	o0	4	72	16.21	o0	9	67	82.066	0
249 Exp.	0	76			0	76			0	76			0	76			0	76		
247 Obs.	50	0	-	-	50	0	-	-	48	2	4.080	.05-.02	50	0	-	-	50	0	-	-
247 Exp.	50	0			50	0			50	0			50	0			50	0		

Secondary division points in the frequency distributions shown in Table 5 permit classification into small, intermediate, and large groups. In seed cotton weight these groupings are 15 to 30, small; 35 to 60, intermediate; and 65 to 95, large. In lint weight 2 to 6 constitute the small group; 8 to 24, the intermediate; and 26 to 30, the large class. In seed index the intermediate class ranges from 10 to 14 (10.5 to 13.5, inclusive) with the small ranging down to 7.5 and the large up to 20. The large number of plants in Progeny 235 with seeds heavier than its parent indicates that Plant No. 3 has accumulated a group of plus modifiers that extends the range upwards and tends to make this character difficult to classify. Number of seeds divides nicely into groups of 100 to 180, 200 to 300, and 320 to 420 for the small, intermediate and large groupings, respectively. Lint index was split between 3.0 and 3.5 and between 6.5 and 7.0 to set off the small, intermediate, and large classes.

Table 7 gives a summary of the segregation of each of these five characters into small, intermediate, and large classes. Assuming that Plant No. 3 and Stoneville are homozygous for large factors, and that Plant No. 6 and Hopi are homozygous for small factors in each of these five characters, the table shows that only in the case of lint index in Progeny 249 did the observed frequency fit the expected. Tables 6 and 7, when considered together, show that each character is apparently controlled by more than one pair of

Table 7. Segregation of each of the five characters used to indicate the inheritance of boll size into small, intermediate, and large classes in the progenies of two segregates of a complex cotton hybrid, Plant No. 3, large boll type, and Plant No. 6, small boll type, and of their crosses with Stoneville (large boll type) and with Hopi (small boll type).

	Seed Cotton Weight					Lint Weight					Seed Index					Number of Seeds					Lint Index				
	Sm.	Int.	Lrg.	X^2	P	Sm.	Int.	Lrg.	X^2	P	Sm.	Int.	Lrg.	X^2	P	Sm.	Int.	Lrg.	X^2	P	Sm.	Int.	Lrg.	X^2	P
Obs.	-	25	138			-	134	29			-	33	127			1	79	83			-	89	74		
235				628.8	∞					∞					∞				6279.3	∞					∞
Exp.	0	0	163			0	0	163			0	0	163			0	0	163			0	0	163		
Obs.	-	6	156			-	22	140			-	61	101			-	2	160			-	72	90		
243					∞					∞					∞				4.025	.05-.02					∞
Exp.	-	0	162			-	0	162			-	0	162			-	0	162			-	0	162		
Obs.	36	124				3	157				0	124	36			23	137				0	160			
246					∞					∞					∞					∞				-	-
Exp.	0	160				0	160				0	160	0			0	160				0	160			
Obs.	23	24				7	40				34	13				8	39				2	45			
238					∞					∞					∞					∞					∞
Exp.	47	0				47	0				47	0				47	0				47	0			
Obs.	3	70	3			1	74	1			16	60	0			0	40	36			0	69	7		
249					∞				2.053	.10					∞					∞					∞
Exp.	0	76	0			0	76	0			0	76	0			0	76	0			0	76	0		
Obs.	49	1				48	2				17	33				42	8				25	25			
247																									
Exp.	50	0		1.02	.30	50	0		4.08	.05-.02	50	0			∞	50	0			∞	50	0			∞

allelomorphic factors. The possibility of linkage among these five characters has been ignored, as proof of linkage would require additional data from further experiments.

ASSOCIATED INHERITANCE

To the experienced plant breeder, the original data of these six progenies suggested that linkage would not explain the boll size inheritance observed. A theory more in fitting with the observed facts is that the combined effect of several factors, each factor capable of independent inheritance and assortment free of linkage, determined the boll size. The term "associated inheritance," suggested by Professor Bryan, is used to distinguish this type of inheritance from linkage, and other similar types. Assuming that dominant size factors A A[2] result in a character being large; that the heterozygous A a factors determine an intermediate expression of a character; and that the homozygous recessive factors a a determine the small expression of a character; and that the resulting size is dependent upon the proportions of A's to a's, a five character association would have eleven possible combinations. These range from the all recessive 10 a - 0 A to the all dominant 0 a - 10 A. The lower three

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2. The symbol Bs was originally selected to represent the boll size factor in an attempt to conform to the suggested outline of gene symbols for cotton by Hutchinson and Silow (Jour. Heredity 30:10:461-464, October, 1939). However, Smith in a recent publication used Bs as a symbol

classes, 10 a - 0 A, 9 a - 1 A, and 8 a - 2 A, are assumed to constitute the group with small bolls; the upper three classes, 2 a - 8 A, 1 a - 9 A, and 0 a - 10 A, the large bolled group; and the intervening classes, 7 a - 3 A, 6 a - 4 A, 5 a - 5 A, 4 a - 6 A, and 3 a - 7 A, constitute the group of plants with intermediate sized bolls.

In the following discussion A_a or a_a represents seed cotton weight; A_b or a_b, lint weight; A_c or a_c, seed index; A_d or a_d, number of seeds; and A_e or a_e, lint index. Using the divisions of the frequencies given in Table 5 into small, intermediate, and large (pp. 13, 14), the genetic symbol for these five associated characters was determined for each of the 658 plants in the six progenies in this study. In addition Plant No. 3 was found to be $A_aA_a\ A_ba_b\ A_cA_c\ A_dA_d\ A_ea_e$; Plant No. 6 to be $A_aa_a\ A_ba_b\ a_ca_c\ A_da_d\ A_ea_e$; Stoneville to be $A_aA_a\ A_bA_b\ A_ca_c\ A_dA_d\ A_ea_e$; and Hopi to be $a_aa_a\ a_ba_b\ a_ca_c\ a_da_d\ a_ea_e$.

In calculating the expected ratios of a to A for progenies of No. 3 selfed and for No. 3 x Stoneville, the binomial $(a+A)^4$ was expanded and 6 A added to each term; i.e., the first term, 1 4a-0A with 6 A added to it becomes 1 4a-6A; for the progeny of No. 3 x Hopi, 5a-3A was added

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2. (cont.) for the boll surface factor he described. (E. Gordon Smith, "Inheritance of Smooth and Pitted Bolls in Pima Cotton," Jour. Agri. Res. 64:2:101-103, 1942). Therefore A,a has been adopted as the symbol for size from the old French "assise."

to each term of $(a+A)^2$ expanded; for progeny of No. 6 selfed, 2 a was added to each term of the expanded $(a+A)^8$; for No. 6 x Stoneville, 1a-3A was added to each term of $(a+A)^6$ expanded; and for No. 6 x Hopi, 6 a was added to each term of $(a+A)^4$ expanded. The observed and expected ratios of a to A for a five factor association of boll size allels are given in Table 8.

In determining the classification of the individual plants, it was observed that often a character of a progeny had many of its plants adjacent to the line dividing classifications. For example, Plant 253 in Progeny 235 with a lint index of 6.7 was classed as $A_e a_e$, while the next plant with an index of 6.8 was given $A_e A_e$. Soil fertility and other physiological influences affect the expression of these characters, and it is probable that what may be the natural dividing line for most of the plants in a progeny will be wrong for a few of the plants. In the classification here reported, the same dividing line was used for all six progenies. Also, the indications that these characters were each determined by more than one pair of allelomorphic genes have been ignored in making the classification. In an attempt to iron out these uncontrolled discrepancies, the classes were summarized into small, intermediate, and large groups. These are shown in Table 9, where it will be seen that the values of x^2 have been reduced until the departures from the expected are no longer significant.

Table 8. Observed and expected frequency distributions of the a:A ratios in a five factor associated inheritance of boll size in the progenies of two segregates of a complex cotton hybrid and of their crosses with Stoneville and with Hopi.

Progeny		Ratios											X^2	P
		10a-0A	9a-1A	8a-2A	7a-3A	6a-4A	5a-5A	4a-6A	3a-7A	2a-8A	1a-9A	0a-10A		
235	Observed						3	15	42	80	22	1	33.9654	.01-
	Expected						-	10.2	40.7	61.2	40.7	10.2		
243	Observed							5	57	36	31	33	73.9400	.01-
	Expected							10.1	40.3	61.2	40.3	10.1		
246	Observed					2	11	123	24				291.8375	0
	Expected					40	80	40						
238	Observed		4	3	9	18	13						15.2198	.05
	Expected	0.2	1.5	5.2	10.2	12.8	10.2	5.2	1.5	0.2				
249	Observed					8	27	31	7	2	0	1	19.9782	.01-
	Expected				1	7	18	24	18	7	1			
247	Observed	6	13	20	5	5	1						9.4740	.05
	Expected	3.1	12.5	18.8	12.5	3.1								

Table 9. Summary of frequencies observed and expected of ratios of a:A into small, intermediate, and large groups in a five factor associated inheritance of boll size in progenies of two segregates of a complex cotton hybrid and of their crosses with Stoneville and with Hopi

Progeny		Small	Inter-mediate	Large	X^2	P
235	Observed		60	103	2.3656	.10
	Expected		50.9	112.1		
243	Observed		62	100	3.8755	.05
	Expected		50.4	111.6		
246	Observed		160		-	-
	Expected		160			
238	Observed	7	40	0	0.2170	.90
	Expected	6.9	39.9	0.2		
249	Observed		73	3	3.4926	.05
	Expected		68	8		
247	Observed	39	11		1.9715	.10-.20
	Expected	34.4	15.6			

SUMMARY

Associated inheritance, or the combined effect of several factors with each factor capable of independent inheritance and assortment, is offered as an explanation of size inheritance. An example of a five factor associated inheritance of boll size of cotton is presented.

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