

THE GENETICS OF COTTON
XVII. INCREASED MUTABILITY OF A GENE IN
G. PURPURASCENS AS A CONSEQUENCE OF
HYBRIDIZATION WITH *G. HIRSUTUM*

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(With Plate IV)

INTRODUCTION

RECENT investigations (Harland, 1936) have led to the conclusion that different species in the genus *Gossypium* are characterized by what may be termed differences in genetical architecture. It may be assumed that each species has a large number of genes, most of which have only a minute physiological or morphological effect; that these genes constitute a harmoniously working system as a result of natural selection and that the particular constellation of genes in two species may be so different as to lead to disharmonious combinations as a result of crossing.

Consequently the degree of divergence of two species in the genus may be assessed by the extent to which they differ in their genetical architecture, and this again may be assessed by the amount of blending or fractionation which occurs when two species with markedly different types of genetical architecture are crossed.

In this connexion the behaviour of genes when transferred from the genetical background of one species to that of another is of extreme interest, since genes which function harmoniously on their own specific background¹ and seem to be identical may by this method be demonstrated to be different.

The present paper deals with certain experiments having as their main object the transference of the character petal spot from one species to another.

The New World allopolyploid species of *Gossypium*, *G. barbadense* Linn., *G. hirsutum* Linn., *G. purpurascens* Poir. and *G. Darwinii* Watt, all include types with a large reddish purple spot at the base of the petal. Previous investigations have shown that presence and absence of petal

¹ "Background" is here taken to signify genetic background, i.e. the genetic complex characterizing a given species.

spot form an allelomorphous pair of characters in all the species, and that the genes for spot are not necessarily identical, but may be alleles of different strengths belonging to the anthocyanin multiple allel series of which several members are known (Harland, 1929, 1936).

The known spot genes at present are S^B (*barbadense* spot) and S^H (*hirsutum* spot). It is incidentally demonstrated in this paper that S^P (*purpurascens* spot) is another allel at the same locus differing from both S^H and S^B in that its manifestation on a *hirsutum* background is stronger than that of S^B but weaker than that of S^H .

It is here shown also that the spot genes exhibit different degrees of mutability on the genetical background of *G. hirsutum*, and more especially that the gene S^P for petal spot in *G. purpurascens* Poir. becomes more mutable when transferred to the genetical background of *G. hirsutum* Linn.

MATERIAL AND METHODS

Three species were used in the experiments, and the taxonomy is that of the writer (1932).

G. hirsutum Linn. is the ordinary annual type of Upland cotton grown in the southern United States. Practically all commercial varieties are devoid of petal spot, though spotted plants are not infrequent in some of the older varieties. Upland cotton is essentially a product of human selection, since the annual habit and lack of resistance to certain pests and diseases render it unfit to survive in a wild state. Both spotted and spotless forms were employed.

G. purpurascens Poir., known as the Bourbon cotton, is an extremely hardy and vigorous tree cotton with a wide geographical distribution ranging from Florida, through Central America and the West Indies, to North Brazil, and Ecuador. It exists in an enormous number of forms, and not only is it found in a truly wild condition but the cultivated forms can reproduce for an indefinite period in a wild state. Three forms with petal spot were used in the present experiments, from the West Indies, Eastern Colombia and Ecuador respectively.

G. barbadense Linn. The form used in these experiments was a vigorous tree cotton from Jamaica known as Cauto cotton.

Petal spot was estimated by using the twenty-two grades of spot employed in previous investigations (Harland, 1929).

At least three flowers were examined from each plant, and the highest mean grade encountered was used in compiling the frequency distributions. Ten or more flowers were used in the special somatic mutability experiments.

EXPERIMENTAL RESULTS

The experimental results deal with the behaviour of

- (1) S^H (*hirsutum* spot) on a *hirsutum* background.
- (2) S^H (*hirsutum* spot) on a background predominantly *barbadense*.
- (3) S^P (*purpurascens* spot) on a *hirsutum* background.

GRADE OF SPOT OF PARENTAL SPECIES

According to the writer's standard grades (1929) the grade of spot in both *hirsutum* and *purpurascens* was from 14 to 16.

- (1) *Behaviour of the gene S^H (hirsutum petal spot) in the hirsutum genotype*

The results of a back-cross of *hirsutum* spotted \times spotless to recessive spotless are set out in Table I below.

This table contains the frequency arrays for grade of spot of fourteen families, the number of spotted (S^Hs) and spotless (ss) plants, and the number of cases of somatic mutation recorded. Somatic mutability is of frequent occurrence in these experiments and it may be stated that it is manifested in heterozygotes in one or more of the following ways:

(a) The appearance of a streak of unpigmented (s) tissue across the petal spot. This streak may be very narrow, or else involve most of the spot.

(b) The presence of one or more spotless petals in a flower.

(c) The production of flowers wholly spotless.

(d) The production of whole branches with spotless flowers.

The main points brought out by Table I are as follows:

(1) S^H is slightly mutable somatically in a heterozygous condition, four undoubted S^Hs plants being observed with one or more completely spotless flowers, or with one or more spotless petals in a single flower. Since only three flowers were examined for petal spot the full extent of somatic mutability of S^H is probably not brought out by the results and it is certain that more plants would have shown mutability had a larger number of flowers been examined.

(2) There is a tendency to an excess of spotless plants in two families and it is possible that the mutability of S^H extended to the gametes in these families. The ratio of spotted to spotless in the total number of plants recorded is $400S^H : 419s$, a slight but insignificant excess of s .

- (2) *Behaviour of the gene S^H (hirsutum petal spot) when transferred to *G. barbadense**

The results of the first back-cross of *hirsutum* spotted (S^H) \times *barbadense* (faintly spotted) to *barbadense* (s) faintly spotted are given below in Table II.

TABLE I
Spot grade in first back-cross (hirsutum S^H × hirsutum s) × hirsutum s

Family	Grade of spot																			S	s	Somatic somatic	Non-somatic	
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18					19
G 37 × 5	22	.	.	.	.	.	.	.	.	.	.	.	.	3	2	13	1	4	5	1	29	22	1	28
G 38 × 5	32	.	.	.	.	.	.	.	.	.	.	.	.	2	3	9	8	4	.	.	26	32	0	26
G 39 × 5	11	.	.	.	.	.	.	.	.	.	.	.	.	1	2	3	5	1	2	.	14	11	0	14
G 40 × 5	11	.	.	.	.	.	.	.	.	.	.	.	.	1	1	6	2	2	1	.	13	11	1	12
G 41 × 5	66	.	.	.	.	.	.	.	.	.	.	.	.	1	3	5	8	0	4	.	55	56	0	55
G 42 × 5	28	.	.	.	.	.	.	.	.	.	.	.	.	3	7	8	6	3	.	.	27	28	1	26
G 43 × 5	14	.	.	.	.	.	.	.	.	.	.	.	.	1	1	3	7	9	2	.	25	14	0	25
G 44 × 5	84	.	.	.	.	.	.	.	.	.	.	.	.	1	1	8	15	11	7	2	46	84	0	46
G 45 × 5	81	.	.	.	.	.	.	.	.	.	.	.	.	1	5	9	10	10	5	4	53	81	1	52
G 46 × 5	12	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	2	5	.	.	11	12	0	11
G 47 × 5	36	.	.	.	.	.	.	.	.	.	.	.	.	3	3	11	2	5	3	1	28	36	0	28
G 48 × 5	22	.	.	.	.	.	.	.	.	.	.	.	.	2	1	2	1	3	1	.	10	22	0	10
G 49 × 5	7	.	.	.	.	.	.	.	.	.	.	.	.	1	2	2	4	1	.	.	10	7	0	10
G 50 × 5	53	.	.	.	.	.	.	.	.	.	.	.	.	2	2	3	5	15	12	9	53	53	0	53
Total	419	.	.	.	.	.	.	.	.	3	5	10	30	64	132	81	57	26	2	496	419	4	396	

TABLE II

First back-cross (hirsutum SH × barbadosense s) × barbadosense s

Family	Grade of spot																				S	s	Somatic somatic	Non-somatic		
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19					20	21
G 51 × 27	1	1														2	1	1	3	5	2		11	9	0	11
G 52 × 27	5	1	2													1	1	3	3	3	2		9	8	0	9
G 53 × 27	14	8													1	3	5	2	2	1			14	17	0	14
G 56 × 27	5	1	1	3												1	1	1	2	2			10	10	0	10
G 57 × 27	5	1	1													2	1	1	1	1			5	8	1	4
G 58 × 27	12		1											1	1	3	1	3	2	5	1	1	18	14	0	18
G 60 × 27	5	1	1													1	1	1	1	1			14	8	0	14
G 61 × 27	5	1	1	1												1	1	1	1	1			6	7	0	6
G 62 × 27	13	1	1	1											1	1	2	2	4	3	1		7	17	0	7
G 63 × 27	11	1	1	1												1	2	3	1	1			18	14	0	18
G 64 × 27	7	1	1													1	1	1	1	1			6	8	0	6
G 65 × 27	6	1														1	1	1	1	1			7	9	0	7
G 67 × 27	9																1	1	1	1			6	8	0	6
G 68 × 27	4																1	1	1	1			4	9	0	4
G 69 × 27	4																1	1	1	1			4	9	0	4
G 70 × 27	6																1	1	1	1			6	7	0	6
G 71 × 27	7																1	1	1	1			9	9	0	9
G 72 × 27	6																1	1	1	1			7	8	0	7
G 73 × 27	7																1	1	1	1			10	7	0	10
G 74 × 27	3																1	1	1	1			11	5	0	11
G 76 × 27	6	1	1														1	1	1	1			3	9	0	3
G 77 × 27	6	1															1	1	1	1			8	8	0	8
G 78 × 27	4	1															1	1	1	1			6	5	0	6
G 79 × 27	5																1	1	1	1			7	10	0	7
G 80 × 27	5																1	1	1	1			8	6	0	8
G 81 × 27	14	2															1	1	1	1			3	16	0	3
G 82 × 27	7	1	3	2													1	1	1	1			7	14	0	7
G 83 × 27	3	1	1														1	1	1	1			6	5	0	6
G 84 × 27	9																1	1	1	1			4	9	0	4
G 86 × 27	1																1	1	1	1			7	7	0	7
G 87 × 27	10	1	1	1													1	1	1	1			14	13	0	14
G 92 × 27	5	1															1	1	1	1			6	10	0	6
G 93 × 27	4																1	1	1	1			3	5	0	3
G 94 × 27	3																1	1	1	1			4	3	0	4
G 95 × 27	14	1	1	0													1	1	1	1			24	25	1	23
G 96 × 27	6																1	1	1	1			5	10	0	5
G 98 × 27	4																1	1	1	1			5	4	0	5
G 99 × 27	4																1	1	1	1			5	10	0	5
G 100 × 27	7	1	1														1	1	1	1			4	8	0	4
G 101 × 27	2																1	1	1	1			18	7	0	18
G 103 × 27	6																1	1	1	1			3	11	0	3
G 105 × 27	7	2															1	1	1	1			11	8	0	11
G 106 × 27	4	1															1	1	1	1			10	12	0	10
G 107 × 27	10																1	1	1	1			10	14	0	10
G 108 × 27	5																1	1	1	1			10	14	0	10
G 109 × 27	8	1															1	1	1	1			10	5	0	10
G 110 × 27	4																1	1	1	1			7	4	0	7
Total	285	23	23	27	8	12	16	8	0		3	1	6	7	10	50	68	63	100	53	8	1	379	408	2	377

The main points regarding the above table are as follows:

(1) Segregation does not occur into spotted and spotless, but into spotted and *less spotted*. The *barbadense* recessive (*s*), used in the experiments, occasionally produces an exceedingly faint grade of spot (up to grade 2). The recessive class here fluctuates from grade 0 to grade 8, with a strong mode at 0, and the variation is due to the fact that *barbadense* possesses a series of plus modifiers for spot which are here interacting with genes from *hirsutum* to produce higher grades of spot than is normally exhibited by spotless *barbadense*. It may be mentioned in support of this explanation that the F_1 of spotless *barbadense* × spotless *hirsutum* is faintly spotted (grades 0-4) and that through recombination of modifiers the F_2 contains plants with spot grade as high as 10.

(2) The ratio of spotted to relatively spotless is 379 : 408, a close approximation to a 1 : 1 ratio, but with a slight excess of recessives.

(3) Two cases of somatic mutability were encountered.

(3) *Behaviour of the gene S^P (purpurascens petal spot)
in the hirsutum genotype*

The following results were obtained in the course of experiments to transfer the petal spot of *G. purpurascens* to the genetical background of *G. hirsutum*. The method adopted was the usual one of back-crossing the heterozygote several times to the recessive, and in some cases results are available for the third successive back-cross.

A. *Transference of S^P from purpurascens (T 26 from Colombia) to hirsutum T 57.*

F_1 . Spotted but grades not noted.

The results of the first, second and third back-crosses are presented in Table III.

The above table contains the ratio of spotted to spotless flowers in each family and also the number of plants in which somatic mutation from *S^P* to *s* was observed.

Somatic mutability could not be recorded in the F_1 or first back-cross, but for the third back-cross the results are fairly complete, being based on an examination of ten or more flowers from each plant.

The following are the main points regarding the results in Table III:

(1) In contrast with the slight mutability of the gene *S^P* on a *hirsutum* background, a considerable number of *S^P*s plants are seen to be somatically mutable in the second and third back-crosses.

TABLE III

Grade of spot of the heterozygote S^{Ps} in successive back-crosses of purpurascens T 26 to hirsutum T 57

Generation	Family ♀*	Spot grade of parent	Grade of spot																	S	s	Somatic	Non-somatic								
			13	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15					16							
<i>F</i> ₁	5 × 26																														
First back-cross	5 × G 937																														
Second back-cross	4714 × 3673	9	6						1	1	2																				
	4730 × 3673	9	14							1	2	4	4	1																	
	4710 × 3676	13	7								1	3	3	4																	
Third back-cross	4704 × 1272	11	14								2	2	3																		
	4706 × 1272	11	31								1	2	4	2																	
	5877 × 1272	11	16								1	4	1	2	1																
	4707 × 1283	6	20								2	6	5	3	1																
	5901 × 1283	6	19								1	1	4	4	1																
	5838 × 1283	6	15								2	3	3	3	1																
	4706 × 1292	10	11								1	3	2	1	3	2															
	4706 × 1292	10	12								1	2	3	2	2	1															
	5903 × 1292	10	29																												
	5906 × 1292	10	27																												
	4704 × 1298	7	52																												
	5907 × 1298	7	63																												
	4706 × 1304	10	27								3	1																			
	5905 × 1304	10	25								2	2	3	3	2																
	5913 × 1304	10	16								2	3	2	2	2																
	4712 × 1306	10	34								1	2																			
	5888 × 1306	10	12								2	1	1	4	3	2															
	5890 × 1306	10	16								1	2	2	4	3																
	4706 × 1307	10	41																												
	4711 × 1307	10	63																												
	4716 × 1308	11	30																												
	5881 × 1308	11	41																												
	5885 × 1308	11	33																												

* The female parent used in the crosses is placed first, and the male parent is often used more than once on different, usually sister plants, of *hirsutum* T 57.

TABLE IV
Grades of spot of the heterozygote SPs in successive back-crosses of purpurascens T 159 to hinsutum T 57

Generation	Family	Spot grade of parent	Grade of spot																	S	s	Somatic	Non-somatic						
			0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16										
F_1	5 x 159	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
First back-cross	5 x G 889	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Second back-cross	4716 x 3626	10	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	4718 x 3626	10	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	4721 x 3626	10	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	4704 x 1218	8	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Third back-cross	4710 x 1218	9	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	5809 x 1219	7	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	5909 x 1219	7	21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	5915 x 1219	7	23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	4710 x 1233	9	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	5923 x 1233	9	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	5911 x 1234	9	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	5912 x 1234	9	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	5918 x 1234	9	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	5873 x 1238	8	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	5880 x 1238	8	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	5883 x 1238	8	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	5884 x 1239	6	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	5885 x 1239	6	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	5889 x 1239	6	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	4710 x 1236	7	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	4711 x 1236	7	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	5881 x 1236	7	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	4711 x 1239	6	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	5884 x 1239	6	39	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	5889 x 1239	6	23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

In one flower of grade 14 from the spotted region a clear unspotted sector passed right through the spot, showing a further tendency to somatic mutation in this region. It was evident that 3686 had mutated somatically to spotless in one branch. The two spotted flowers subsequently recorded on this branch indicate either that a reversion to S^P had taken place or that a sector containing S^P persisted in the spotless branch. The latter explanation appears the more probable.

Twelve spotted and spotless flowers were self-fertilized and cultures grown from each individual boll. The results are given in Table VI.

From the results it will be seen that all bolls gave rise to spotted and spotless plants with the exception of boll 8, which gave 9 spotless and 1 doubtful spot, showing that mutation had extended to the gametes. In the two progenies from spotless flowers a deficiency of spotless occurs, though this may not be significant.

Twenty mutable and ten non-mutable plants were examined daily and the grades recorded. The results are given in Table VII.

From Table VII it is evident that a clear line of division separates mutable and non-mutable plants. One-third of the selfed offspring of plant 3686 are expected to be homozygous spot $S^P S^P$ in which somatic mutation would only be observed if both the spot loci mutated. The actual ratio obtained of 26 mutable to 49 stable seems to indicate that many of the heterozygotes are not mutable.

COMPARISON BETWEEN *HIRSUTUM* SPOT S^H AND *PURPURASCENS*
SPOT S^P ON A *HIRSUTUM* BACKGROUND

Although it is evident from the results already presented that three back-crosses to *hirsutum* are not sufficient to stabilize the *purpurascens* gene S^P in the *hirsutum* background, some results may be put forward comparing the mean grade of *hirsutum* spot S^H s and the mean grade of *purpurascens* spot S^P s as far as the third back-cross, when most of the genes should be those of *hirsutum*. The comparison follows:

Genotype	No. of back-cross	No. of families	Mean spot grade
S^H s	1	1	15.3
S^P s (T 13)	1	1	13.0
	2	6	8.9
	3	20	6.6
S^P s (T 159)	F_1	1	14.0
	1	1	11.8
	2	3	10.0
	3	20	5.4

The above results indicate that, on a *hirsutum* background, the intensity of the spot gene S^P is weaker than that of S^H , and it is thus

TABLE VI

Results of self-fertilizing spotted and spotless flowers on the second back-cross. Somatic plant G 3686

No. of boil	Flower Spotted	Spot grade	Grade of spot																S	s	Somatic somatic	Non- somatic		
			0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15					16	
1		11	4	1	1	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.	5	4	4	1
2		11	5	.	.	.	.	.	1	1	1	1	1	1	1	1	1	1	1	1	7	5	2	5
3		13	1	.	.	.	.	.	1	1	1	1	1	1	1	1	1	1	1	1	3	1	3	0
4		13	5	1	1	.	.	.	1	2	1	1	1	1	1	1	1	1	1	1	7	5	3	3
5		13	4	.	.	.	.	.	2	2	1	1	1	1	1	1	1	1	1	1	4	4	4	0
6		13	7	.	.	.	.	.	2	2	1	1	1	1	1	1	1	1	1	1	6	7	3	4
7		14	8	.	.	.	.	.	1	1	1	1	1	1	1	1	1	1	1	1	4	8	1	3
8		14	9	1	.	.	.	.	1	1	1	1	1	1	1	1	1	1	1	1	1	9	1	3
9		14	12	.	.	.	.	.	1	1	1	1	1	1	1	1	1	1	1	1	7	12	4	3
10		15	0	.	.	.	.	.	1	1	2	1	1	1	1	1	1	1	1	1	9	9	2	7
1	Spotless	0	4	.	.	.	.	.	1	1	1	1	1	1	1	1	1	1	1	1	14	4	1	13
2		0	6	.	.	.	.	.	1	1	2	1	1	1	1	1	1	1	1	1	10	6	1	9

TABLE VII

Results of examination of twenty mutable and ten non-mutable plants in 3686 selfed

Type of plant	No. of flowers examined	Grade of spot																	
		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Mutable	10	6	.	.	2	.	1	1	.	.	1	.	.	.	.	.	.	.	.
	8	7	3	2	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.
	10	5	3	2	.	.	.	.	.	.	.	.	.	.	.	.	4	1	.
	13	1	2	1	2	.	.	.	.	.	.	.	1	2	2	1	.	.	.
	14	1	1	5	1	.	.	2	1	.	4	6	.	.	.	.	.	.	.
	20	7	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.
	14	10	.	.	.	.	1	1	.	.	1	.	.	1	.	.	.	.	.
	15	14	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	14	3	1	.	.	1	3	5	1	.	.	.	.	.	.	.	.	.	.
	8	6	1	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.
	13	10	2	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
	10	8	.	.	2	1	.	.	.	.	.	.	.	.	.	.	.	.	.
	21	7	4	3	1	.	.	.	1	1	.	4	.	.	.	1	.	.	.
	9	3	2	1	1	.	.	.	.	.	.	1	4	1	.	.	.	.	.
	22	4	.	.	.	.	.	1	.	.	.	1	.	1	.	.	.	.	.
	11	10	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.
	10	6	.	.	.	.	.	.	.	1	1	2	.	.	.	.	.	.	.
	16	13	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.
	13	1	.	.	1	.	4	1	3	.	.	1	1	.	.	.	.	.	.
	11	6	.	.	.	.	1	3	1	.	.	.	.	.	.	.	.	.	.
	Non-mutable	10	.	.	.	.	.	.	.	3	2	4	1	.	.	.	.	.	.
		10	.	.	.	.	.	.	.	1	3	4	1	1	.	.	.	.	.
10		.	.	.	.	.	.	.	.	.	4	1	3	4	2	.	.	.	
8		.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.
10		.	.	.	.	.	.	.	.	.	.	3	.	1	1	1	5	3	
10		.	.	.	.	.	.	.	.	.	.	1	3	.	.	.	.	.
10		.	.	.	.	.	.	.	.	.	.	2	1	1	2	.	.	.	
8		.	.	.	.	.	.	.	.	.	.	1	4	1	1	.	.	.	
11		.	.	.	.	.	.	.	.	.	.	1	1	1	2	2	.	.	
11		.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	6	.	
11		.	.	.	.	.	.	.	.	.	.	3	6	.	.	.	.	.

clear that S^H and S^P are different genes. That they are both members of the anthocyanin multiple allel series follows from the fact that they are both (on unpublished evidence) allelomorphic to R^B (*barbadense* red plant body).

DISCUSSION

The main points of importance brought out by these experiments may be summarized. They are:

(1) The progressive weakening of the manifestation of the *purpurascens* spot gene S^P on a *hirsutum* background, with no corresponding weakening of the *hirsutum* spot gene on a background predominantly *barbadense*.

(2) The extreme tendency to both somatic and gametic mutation exhibited by the *purpurascens* spot gene on a *hirsutum* background, as compared with the slight mutability shown by the *hirsutum* spot gene on the same background.

A satisfactory explanation for the manifestation of spot at a lesser degree of intensity was previously put forward (1935) for a case of the same type, viz. the complete disappearance of petal spot and diminution in the intensity of anthocyanin pigmentation which accompanied the transference of the *arboreum* gene R^A to a *hirsutum* background. The explanation of the weakening of *purpurascens* spot S^P is essentially the same, namely that S^P is accompanied in *purpurascens* by a series of plus modifiers which augment its effect, that these modifiers are absent in *hirsutum*, and that transference to *hirsutum* causes the gene S^P to be stripped of its modifier complex.

In regard to the extreme instability of the *purpurascens* S^P gene on the *hirsutum* background, it seems that this phenomenon is also progressive, and that it is due to the substitution of *hirsutum* for *purpurascens* genes. We have abundant evidence from other crosses that stability of the gene S^P is only slightly affected in the first back-cross to *hirsutum*. It is only when the background becomes preponderantly *hirsutum* that the extreme type of instability appears. It therefore seems possible that the gene S^P is accompanied in *purpurascens* by some other genes, the combined effect of which is to preserve the stability of S^P and prevent it from mutating at more than a certain rate. However, since little is known of the mutability of S^P in *G. purpurascens* itself, it is inadvisable to attribute general significance to what may be an isolated phenomenon. Nevertheless, if, as previously stated, species in the genus *Gossypium* are characterized by different types of genetical architecture, it is

reasonable to suppose that some of the species possess definite complexes of genes which may be termed stabilizing complexes, functioning in the species to suppress mutability. The existence of such stabilizing complexes is implied in the view put forward by Wright (1932). He pointed out that evolution in a species depends on a certain balance among the factors of gene mutation, selection, inbreeding, and cross-breeding. He says: "There must be gene mutation, but an excessive rate gives an array of freaks, not evolution."

Demerec (1929 and earlier papers) has demonstrated the existence of genes in *Drosophila* which promote or retard the mutability of the so-called mutable genes.

If the stabilizing complexes differ between species it follows that some species alleles (alleles confined to a given species) may become mutable when transferred to the background of another species.

The literature of interspecific hybridization contains a certain number of references to a possible connexion between mutation and the hybrid condition. Baur (1933), referring to his researches on *Antirrhinum*, states that in very strongly heterozygous F_1 individuals factor mutability is significantly increased. For example, in the F_1 of a cross of cultivated *majus* by a member of the *glutinosum* group appear plants which are homozygous recessives in some new gene for which the parents are homozygous dominants, e.g. plants with white flowers. Kostoff (1935*a*) mentions that numerous interspecific crosses in *Nicotiana* have resulted in striping of the flower petals. He concluded that in some hybrids between distantly related species the dominant genes for colour change to their recessive state (white) more often than in the pure species, and that reverse mutations to the dominant type are also more frequent. Thus gene stability appears to be affected by the internal conditions in the hybrid. The same author (1935*b*), in a discussion of heritable tumours in amphidiploids obtained from *N. glauca* \times *N. langsdorffii*, suggests that an increased rate of somatic mutation in the hybrids may be a possible explanation of their occurrence.

The results presented in this paper are of significance to the plant breeder in connexion with the transference of desirable characters from one species to another, for if it is the case that genes of economic value become mutable when so transferred a limit is set to the practical value of species hybrids.

SUMMARY

1. The gene S^H (*hirsutum* petal spot) is slightly mutable somatically on (a) a *hirsutum* background, and (b) a background predominantly *barbadense*.
2. The gene S^P (*purpurascens* petal spot) becomes increasingly mutable, both somatically and gametically, *pari passu* with the replacement of *purpurascens* by *hirsutum* genes.
3. It is believed that species may possess modifier complexes, the effect of which is to preserve the stability of genes and prevent them from mutating at an excessive rate. *Hirsutum* and *purpurascens* may be assumed to differ in the nature of such of their modifiers as affect the mutation rate of S^P .
4. The genes S^H and S^P are members of the anthocyanin multiple allel series, and may be distinguished by the weaker manifestation of S^P in the *hirsutum* genotype.
5. Other cases of mutability in interspecific hybrids are mentioned, and the possible significance to the plant breeder of mutability consequent on interspecific hybridization is referred to.

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EXPLANATION OF PLATE IV

These coloured drawings indicate the 22 grades of petal spot in cotton of which use was made during the investigation.

1 2 3 4

5 6 7 8

9 10 11 12

13 14 15 16

17 18 19 20

21 22