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W. B. BIZZELL, President

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DIVISION OF AGRONOMY

HERITABLE CHLOROPHYLL DEFICIENCIES IN SEEDLING COTTON

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**In cooperation with United States Department of Agriculture.

SYNOPSIS

The purpose of this Bulletin is to report the hereditary behavior of two deficiencies in green coloring matter in seedling cotton. These two characters, one of which is yellow seed leaves instead of the usual green, and the other the lack of green color in certain portions of the seed leaves, are important defects not only because of their fundamental scientific interest but also because the presence of these characters in a field of cotton lessens the stand and vigor of the plants.

The two characters mentioned are shown to be inherited and the relations of the genetic factors concerned have been discovered. These factors thus form a true basis for future genetic work in cotton.

The work presented herein is preliminary to and is only a small part of the genetic study of cotton which is being conducted at this Station.

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HERITABLE CHLOROPHYLL DEFICIENCIES IN SEEDLING COTTON

G. N. Stroman and C. H. Mahoney

Chlorophyll deficiencies have been found in certain individuals of all crop plants which have been even partially genetically analyzed, and have been observed in many others. Chlorophyll characters in maize occupy a rather prominent place in genetic literature (Lindstrom, 1918, 1921; Emerson, 1923; Demeric, 1921; Stroman, 1924a, 1924b).

Cotton has been studied genetically rather extensively but until now, no one has reported deficiencies in the chlorophyll apparatus. The characters studied in cotton have been those of the adult plant and of the seed. The work of Balls (1918) in Egypt; Fyson (1918); Leake (1920; Kottur (1921); and Prasas (1922) in India; and McLendon (1912), and Kearney (1923) in America show some interesting genetic behavior of the adult cotton plant.

The object of this Bulletin is to report the presence of certain heritable chlorophyll deficiencies in seedling cotton, and to give their genetic behavior as far as the results will justify at this time.

Effects of the Amount of Cross Fertilization in the Field Upon the Validity of the Data

Owing to the fact that the detailed data here presented on the genetic behavior of these chlorophyll characters were obtained from plants that had been open-pollinated, it is necessary to estimate the amount of cross-pollination occurring in the field at this Station during the season of 1924.

Cotton pollen is sticky and therefore is not readily transported by the wind. As a result, cross-fertilization in cotton largely depends upon insects, especially bees (Allard, 1910). In the field in 1924 the writers observed very few bees, and these were bumble bees. Allard (1921) stated that cross-fertilization in cotton was directly proportional to the number of bees present. Parks (1921) found, however, that bees seldom visit the cotton bloom for pollen, and when collecting nectar, barely come in contact with the stamens and pistils.

The per cent of cross-fertilization in cotton has been estimated by several workers. Allard (1910), working in Georgia, gives figures showing 13 to 31 per cent of crossing between adjacent rows. He states that on an average, 20 per cent of the bolls were affected by foreign pollen. His data, however, fail to show the per cent of cross-fertilized ovules. Kearney (1923) notes that where insects are abundant, the amount of cross-fertilization in cotton seldom exceeds 20 per cent. He also states that the average percentage of cross-fertilized ovules, under optimum conditions of cross-fertilization, was 12 per cent in Pima (Egyptian), and 28 per cent in Acala (upland). Kottur (1921) states that there is about 6 per cent of cross-fertilization in India cottons at Dwarwar, India. Balls (1918) in Egypt, as an average of a number of years, gives 13.5 per cent of cross-fertilization in cotton between adjacent rows. These observations of other workers are interesting, especially when compared with those made at this Station.

In 1924, one row of material which was segregating for red and non-red or light-red plants was grown. Red plants have intensely red leaves and stems. The non-red or light-red types found in commercial varieties of upland cotton have only faint traces of red at the base of the stem, on the branches, or on the petioles. In the greenhouse, seedlings of these latter types are totally devoid of red color; but the color appears in later stages. Seedlings of red plants, when grown in the greenhouse, have distinct red stems. From records of tests of these characters in the greenhouse, we can estimate the amount of cross-fertilization that occurred in 1924 at our Station.

Family 241, (Egyptian), pure for non-red or light-red color, was grown in 3-foot rows alongside the red-stem plants above mentioned. Eighteen progenies from this family were tested in the greenhouse and over 50 seedlings were grown from each progeny. Out of this total of about 2,000 seedlings, not a single red stem was observed.

Families 247, 248, and 249 in the field, were segregating for red and non-red plants. In each family, we selected one non-red individual growing between two red-stem plants. The seeds from these non-red plants were grown in the greenhouse and the following counts made:

	Red Stem	Non-Red Stem
247(1)	1	65
248(3)	0	23
249(6)	1	77
Total	2	165

Per cent red stems = 1.17

Since the plants which furnished the pollen carrying the factor for red stems were heterozygous, it is necessary to double the observed per cent of red-stem seedlings thus giving 2.34 per cent of natural crossing in these particular plants. (The color of red- and non-red-stem plants has been shown to be inherited in a simple monohybrid condition (Balls, 1918).

Our data on this anthocyanin character, which will be presented in a later bulletin, shows that here in these families there is one basic genetic factor for red- and non-red-stems present. This basic factor is designated herein as the **Aa** factor pair

Further evidence of crossing in the field in 1924 is found in the progeny of two plants pure for non-red-stem seedlings. These two plants, 249(12) and 249(13), grew side by side and 3 feet apart in the row. Now, on the west side of 249(12) was 249(11), which was heterozygous for the **Aa** factor pair, and on the east side of 249(13) grew 249(14), also heterozygous for the

A factor. Seedlings grown from 249(12) and 249(13) totaled 366, of which only 3 were red stems. This is 0.82 per cent of observed crossing under conditions as stated above. We could actually observe only the crossing which resulted from the A male gamete. There were only one-fourth as many male gametes of the A type as there were of the **a** type. Therefore, the theoretical amount of natural crossing was four times 0.82 per cent of 3.28 per cent.

Another plant pure for non-red-stem seedlings, 250(1), throws some further light on the amount of crossing in the field during the season of 1924. On one side of this grew a plant that was pure for red-stem seedlings and on the other, one heterozygous for the A factor. Hence three-fourths of the adjacent male gametes were of the A type and one-fourth of the a type. Here three-fourths of the crossing could be observed. One hundred and fifty-one seedlings from 250(1) were grown, of which 2 had red stems. This is 1.32 per cent, or a theoretical adjacent natural crossing of 1.76 per cent.

Averaging the theoretical per cents of natural cross-fertilization shown above, 2.34, 3.28, and 1.76 per cents we have 2.46 per cent of cross-fertilization taking place between adjacent plants in the same row in the season of 1924 at College Station.

From these observations it is our opinion that the amount of cross-fertilization in 1924, though somewhat variable, was, in general, not large enough to affect seriously the value of the genetic data obtained from open pollinated seed.

Nature of Material

In the fall of 1923, when this work began, seven hybrid rows of cotton were growing in the genetic garden, and from these the material for the study of yellow seedlings was taken. The majority of these hybrids were Egyptian-upland crosses. Yellow seedlings were found in the F_2 from these crosses. The pattern character was found to be present not only in the descendants of these seven rows but also in nearly all other material tested in the greenhouse during the winter of 1923-24.

Study of the Yellow Seedling Character

This character is present in the seedling stage only, and such seedlings die as soon as the stored food of the seed has been used up. It appears as a very light greenish yellow in the young cotyledons as they push through the surface of the soil. The small amount of green pigment soon disappears and the color of the cotyledons becomes a distinct yellow. In some families a portion of the yellow has been observed to disappear from the base of the leaf, thus leaving pure whitish areas. The cotyledons turn entirely white toward the end of the life of the seedling, which is about twelve days when grown in pure sand.

From a cross of Sea Island with Burnett made in 1922 by Dr. Geo. F. Freeman at this Station, the progeny of one F_1 plant growing in the field in 1923 was found to be segregating for yellow seedlings in a proportion of 63 green seedlings to 4 yellow. This is close to a 15:1 ratio. The seed from thirteen of these green plants were planted in the greenhouse in the winter of 1924-1925. The counts of the progenies are found in Table 1.

TABLE 1

Segregation of non-yellow and yellow seedlings in F_3 progenies of a Sea Island by Burnett (upland) cross

Family 216 and Family 217

Plant No.	Non-Yellow	Yellow	Approximate Ratio
216(1)	13	0	pure
(2)	23	0	pure
(4)	20	3	15:1
(6)	16	0	pure
(7)	20	0	pure
(8)	116	43	3:1
(12)	335	0	pure
(13)	7	0	pure
(14)	199	0	pure
(17)	43	4	15:1
217(1)	16	1	15:1
(2)	95	3	15:1
(4)	140	0	pure

Only one 3:1 ratio was observed (216-8) with 116 non-yellows to 43 yellows. Four progenies showing 15:1 ratios were found (216-4, 216-17, 217-1 and 217-2) with a total of 174 non-yellows to 11 yellows. This is almost perfect for a 15:1 ratio. There were 8 progenies not segregating for yellow seedling.

If the original parent of these progenies was heterozygous for two factors and if the double recessive condition only permits the expression of the yellow seedlings, we would expect seven progenies giving only non-yellows, four giving 3:1 ratios, and four giving 15:1 ratios of non-yellow to yellow seedlings. We obtained eight non-yellow progenies to one progeny giving a 3:1 ratio to four progenies giving a 15:1 ratio. This is a fair agreement with the expected $p = 0.32$.

Further evidence that yellow seedlings are determined by the double recessive condition of two factors comes from three separate crosses studied among numerous crosses of Egyptian with Mebane.

A field count of the progeny of an F_1 plant from one of these crosses gave 76 non-yellows to 4 yellows. This approximates a 15:1 ratio. The seed of nine of these non-yellow plants were grown in the greenhouse and counts made as to character of seedling. The counts are found in Table 2.

One progeny, 218-10, gave a 3:1 ratio or a total of 87 non-yellows to 22 yellows, with a deviation only 1.42 times the probable error from the calculated ratio. This indicates a fair probability that the deviation is due to random sampling. Three progenies segregating into 15:1 ratios, with a total of 221 non-yellows and 9 yellows are also shown. The deviation from a 15:1 ratio is 5, the probable error is 2.48, and the deviation divided by the probable error is 2.02. This is only a fair agreement between observed and expected ratios.

TABLE 2

Segregation of non-yellow and yellow seedlings in F_3 progenies of an Egyptian by Mebane (Upland) cross

Family 218

Plant No.	Non-Yellow	Yellow	Approximate Ratio
218(2)	48	0	pure
(3)	19	1	15:1
(10)	87	22	3:1
(11)	173	6	15:1
(13)	25	0	pure
(15)	29	2	15:1
(16)	96	0	pure
(19)	14	0	pure
(20)	83	0	pure

Only nine progenies are shown in Table 2 but the observed ratio of genotypes is close to the expected ratio. If the parent plant was heterozygous for two factors as was indicated, we should expect a ratio of seven progenies pure for non-yellow, four progenies giving 3:1 ratios, and four progenies giving 15:1 ratios. We observed five progenies pure for non-yellow, one progeny giving a 3:1 ratio, and three giving 15:1 ratios, which approximates the expectation.

The second representative of the Egyptian with Mebane crosses (19-2 selfed seed) gave 86 non-yellow and 6 yellow seedlings in the F_2 generation. This is a 15:1 ratio of non-yellow to yellow seedlings. The counts of sixteen progenies from this plant are found in Table 3.

TABLE 3

Segregation of non-yellow and yellow seedlings in F_3 progenies of an Egyptian by Mebane (Upland) cross

Family 220 and Family 221

Plant No.	Non-Yellow	Yellow	Approximate Ratio
220(2)	45	0	pure
(3)	3	0	pure
(4)			pure
(6)	15	1	15:1
(8)	12	1	15:1
(11)	78	1	15:1
(19)	14	0	pure
(21)	26	3	15:1
(24)	10	0	pure
(28)	38	1	15:1
(29)	43	0	pure
(30)	13	0	pure
(32)	57	0	pure
221(3)	33	0	pure
(4)	70	2	15:1
(2)	43	0	pure

The data are similar to those presented in Table 2 with the exception that no 3:1 ratios are found. The total for those progenies segregating gives 239 non-yellow to 9 yellow seedlings. The deviation for this ratio is six and this divided by the P. E. is 2.33. Ten progenies not segregating and six segregating are given. No 3:1 ratios were obtained. The number of progenies is too small to justify any estimate as to whether the non-appearance of 3:1 ratios among them is significant. The deviations from a 15:1 ratio, shown in Table 3, may be accidental.

The third representative of the Egyptian by Mebane crosses is the family of 19-25, selfed seed. This plant gave, in the field F_2 counts of 57 non-yellows and two yellows. The seed from seventeen of these non-yellow plants were planted in the greenhouse and the data are found in Table 4.

TABLE 4

Segregation of non-yellow and yellow seedlings in F_3 progenies of an Egyptian by Mebane (Upland) cross

Family 223

Plant No.	Non-Yellow	Yellow	Approximate Ratio
223(1)	36	1	15:1
(3)	24	0	pure
(4)	21	0	pure
(5)	49	8	15:1
(6)	43	0	pure
(7)	19	1	15:1
(8)	43	1	15:1
(9)	11	0	pure
(10)	23	0	pure
(12)	47	3	15:1
(13)	29	0	pure
(14)	65	2	15:1
(16)	103	0	pure
(17)	24	2	15:1
(18)	24	3	15:1
(19)	12	0	pure
(20)	29	0	pure

Again, no 3:1 ratios of non-yellow to yellow seedlings were observed. The total of these progenies segregating gives 307 non-yellow to 21 yellow seedlings. This is a 15:1 ratio. There are nine progenies pure for non-yellow and eight progenies segregating.

The absence of 3:1 ratios in this family, as well as in the preceding family may possibly be significant, but the present data are insufficient to establish this fact. It is clear, however, that there are two factor pairs involved in the production of yellow seedlings, which will be designated in later writings as $\mathbf{Y_1\ y_1\ \ Y_2\ y_2}$

Study of the Pattern Seedling Character

This type of chlorophyll deficiency is shown by certain areas devoid of green color on the young cotyledons, surrounded by normal green pigment. These areas are not of any uniform shape, but extend usually from the extreme edge half way across the leaf (Fig. 1). The pattern seems to start at the edge of the leaf and in some cases occurs only at this point (Fig. 2). In some families the deficient areas are a rich yellow, and in other families they are white. The light pattern is so called because the young leaves contain areas of light greenish color instead of a yellow or white color (Fig. 3). These light paterns also vary in their area of expression. In some, the areas are as large as the true patterns; but where there is a trace of chlorophyll present in the deficient area, the seedling is classed as a light pattern. There are others that appear more or less mottled, and that have light greenish to greenish yellow areas throughout the green pigment of the leaf. These are called light patterns also.

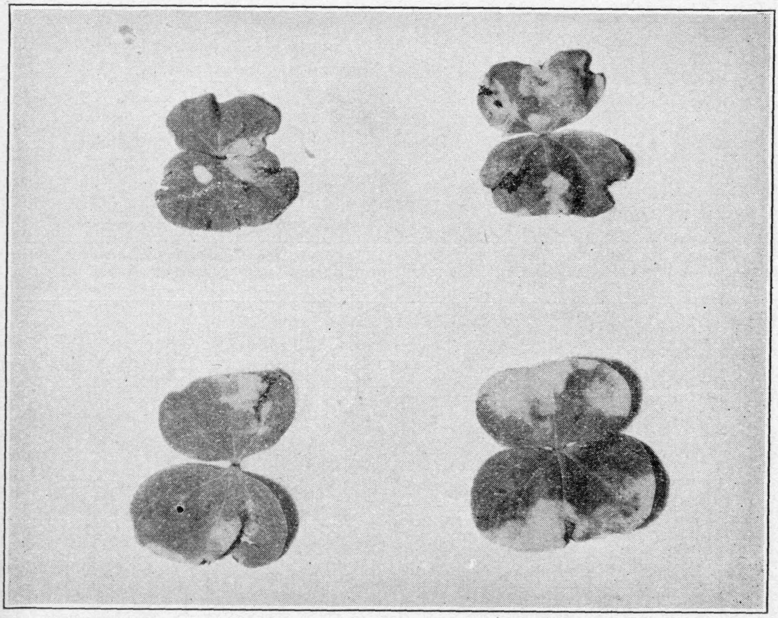

Figure 1. The chlorophyll pattern character in cotton seedlings.

From actual observations, and from the data presented, it seems that these pattern types of cotyledons never mature but observations are confined to field tests in the spring of 1924, which was very unfavorable for the growth of young seedlings in the field. This may account for the fact that there are no light pattern or pure pattern seedlings that developed to produce seed. Most of the patterns are of a defective nature, and while they are not totally without chlorophyll, it may be that there is such a decrease in the number of chloroplasts that the seedling must depend mostly upon the food stored up in the seed.

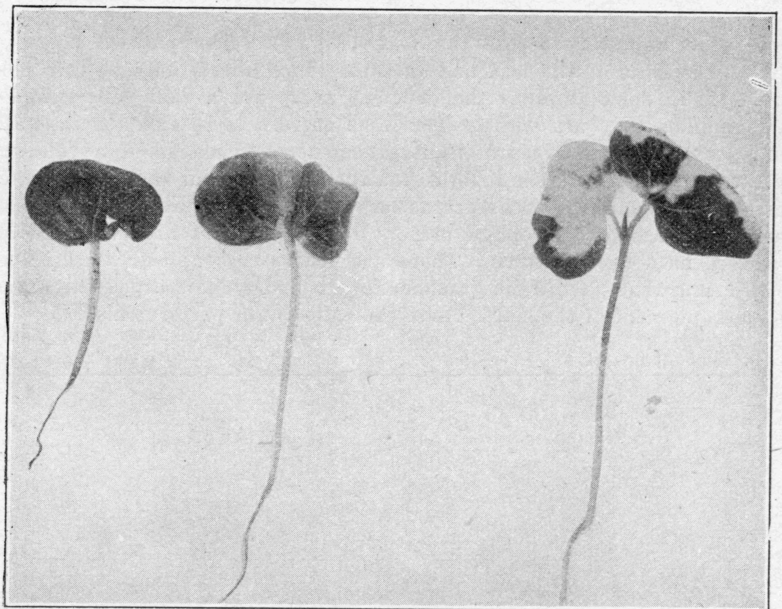

Figure 2. Showing different degrees of expression of pattern character, pure pattern on right, light pattern in center, and normal green leaf on left.

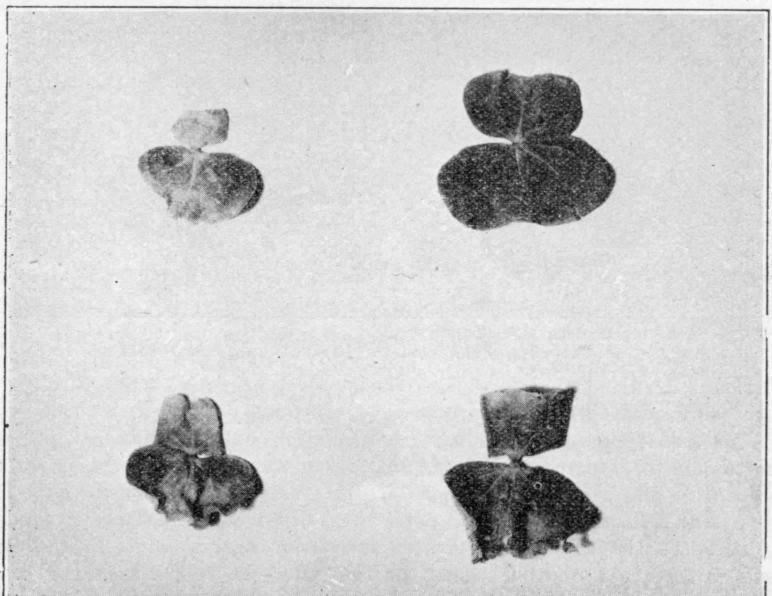

Figure 3. Seedlings showing the light pattern deficiency. Note absence of dark green color.

Inheritance of Pattern Seedling

The families that are presented to show the genetic behavior of this character are selections of 1923, made in the course of the plant-breeding work of the Station. They were observed in the greenhouse during the winter of 1923-1924 to be segregating for patterns. These strains were planted in the field in 1924 and progeny tests made in the greenhouse the winter of 1924-1925.

The first evidence that will be presented is from family M6. The detailed data for this family are shown in Table 15 (appendix) and the summary of results in Table 5.

TABLE 5

Summary of family M6

1. Progenies segregating for two factors

	Dark greens	Light greens	Light patterns	Patterns	Total
Total observed	166	64	54	19	303
Calculated 9:3:3:1	170	57	57	19	303
O-C	4	7	3	0	
P=0.78					

2. Progenies segregating for one factor

	Greens	Light greens or light patterns	
Total observed	188	58	247
Calculated 3:1	185	62	247
O-C	3	3	
$\frac{\text{Dev.}}{\text{P.E.}} = 0.65$			

There are two kinds of ratios obtained in this family. When all four classes, dark greens, light greens, light patterns, and patterns, appeared in the same progeny the classes could be separated easily enough, but when only one defiicient character was present in one progeny the distinction between the light green and the light pattern was impossible so that light greens and light patterns have been grouped together in one class in the latter part of table 5.

For the progenies giving 9:3:3:1: ratio, the observed numbers agree extremely well with the expected numbers, the probability being 0.78; and for those progenies giving a 3:1 ratio of greens to patterns the agreement is also good, the $\frac{\text{Dev.}}{\text{P.E.}}$ being 0.65.

The results of the genotypic progeny test of this family is given in Table 6 and agree well with the expectation. The factors responsible for the pattern in this family have been designated as C_1 and C_2.

TABLE 6

Genotypic progeny test for family M6

Segregating for normal and chlorophyll pattern seedlings

Ratio	Genotypes	Observed	Calculated	Deviation
1	$C_1C_1C_2C_2$	1	1.2	.2
2 2	$C_1C_1C_2c_2$ $C_1c_1C_2C_2$	5	4.8	.2
4	$C_1c_1C_2c_2$	5	4.8	.2

$x^2 = 0.6$

Further evidence that the pattern character is caused by two recessive factors is found in families M1 and M7. The detailed data for these families are given in Tables 16 and 17. The results of the progeny test are given in Table 8. A summary of the two families is given in Table 7.

TABLE 7

Summary of two families, M1 and M7

1. Progenies heterozygous for one factor

Progeny numbers M_{1}-1, 5, 6, 10, 14, 20, and M_{7}-4, 6, 10, 11, 14

	Greens	Patterns	Total
Total Observed	436	162	598
Calculated 3:1	448	150	598
Deviation	—12	12	

$\frac{\text{Dev.}}{\text{P.E.}} = 1.7$

2. Progenies heterozygous for two factors

	Greens	Patterns	Total
Total observed	442	285	727
Calculated 9:7	409	318	727
Deviation	33	—33	

$\frac{\text{Dev.}}{\text{P.E.}} = 3.7$

The observed ratios agreed fairly well with the expected, i. e., those progenies segregating for one factor agreed fairly well with a calculated 3:1 ratio of greens to patterns, while those progenies which apparently segregated for two factors do not agree very closely with a 9:7 ratio of greens to patterns. It is possible that this deviation may be due to a small amount of crossing in the field, which would affect those progenies segregating for two factors more so than those segregating for only one factor. The de-

TABLE 8

Progeny test for families M1 and M7

Ratio	Genotypes	Observed	Calculated	Deviation
1	$C_1C_1C_2C_2$	1	3	2
2	$C_1C_1C_2c_2$	12	11	1
2	$C_1c_1C_2C_2$			
4	$C_1c_1C_2c_2$	12	11	1

$X^2 = 1.52$
$p = 0.48$

viation may also be due to linkage, and for the purpose of comparison the data are fitted to a 33 per cent crossing-over ratio as is given in Tables 9 and 10.

TABLE 9

Summary of families M1 and M7 fitted to a linkage ratio

Progenies M1-2, 4, 12, 13, 19, and M 7-1, 3, 5, 9, 15, 16, 17

	Greens	Patterns	Total
Total observed	442	285	727
Calculated 22:14 ratio 33% C. O.	444	283	727
Deviation	—2	2	

$$\frac{\text{Dev.}}{\text{P.E.}} = \frac{2}{8.9} = 0.22$$

TABLE 10

Genotypic progeny test for families M1 and M7 based on 33% C. O.

Ratio	Genotypes	Observed	Calculated	Deviation
4	$C_1C_1C_2C_2$	1	4.4	3.4
4	$C_1C_1C_2c_2$	12	8.8	3.2
4	$C_1c_1C_2C_2$			
10	$C_1c_1C_2c_2$	12	11.0	1.0

$X^2 = 3.88$
$P = 0.15$

The results of the progeny tests, on the assumption of factor independence, are given in Table 8, and show fair agreement between observed and expected ratios with $p = 0.48$. The agreement, however, between observed and expected ratios based upon linkage is poor; e. g., Table 10 shows only a $p = 0.15$. This leaves it doubtful whether or not linkage really exists between these two factors. If it does exist, at least one of the factors in families M1 and M7 must be different from either of those acting in M6.

Other evidence showing that the pattern seedling character is dependent upon two genetic factors is found in family M10. The summary of this family is given in Table 11. The detailed data are given in Table 18.

TABLE 11

Summary of family M10

1. Showing segregation of progenies M 10-1, 5, 10, 11, 18, 19, and 20

	Greens	Patterns	Total
Total observed	266	72	338
Calculated 3:1 ratio	254	84	338
Deviation	12	—12	

$$\frac{\text{Dev.}}{\text{P.E.}} = \frac{12}{5.4} = 2.2$$

2. Showing segregation of progenies M 10-4, 6, 9, 12, 13, 14, and 16

	Greens	Patterns	Total
Total observed	224	122	346
Calculated 9.7 ratio	195	151	346
Deviation	29	—29	

$$\frac{\text{Dev.}}{\text{P.E.}} = \frac{29}{6.2} = 4.7$$

The observed ratios agree with the expected ratios only fairly well in the case of the 3:1 ratios of greens to patterns and poorly in the case of the 9:7 ratios of greens to patterns. If some of the progenies classified as giving a 9:7 ratio should have been classified as giving a 3:1 ratio (for example family M10-16) then the actual data fit the hypothesis better than these figures would indicate.

TABLE 12

Segregating for normal and chlorophyll pattern seedlings

Ratio	Genotypes	Observed	Calculated	O-C
1	$C_1C_1C_2C_2$	0	1.56	1.56
2	$C_1C_1C_2c_2$	7	6.24	0.76
2	$C_1c_1C_2C_2$			
4	$C_1c_1C_2c_2$	7	6.24	0.76

$X^2 = 1.7452$
$P = 0.4286$

The progeny tests (Table 12) give no pure green progenies, which may possibly be due to the small number of progenies. There were seven progenies that gave 3 greens to 1 pattern, and seven progenies that gave 9 greens to 7 patterns. There were no progenies that gave pure patterns. The observed numbers agree fairly well with the expected with a $P = 0.43$.

The inheritance of the pattern character in another family M15 is somewhat different from any that have yet been presented. The parent of this family came from a field of Mebane cotton but acts somewhat differently from the way families M1 and M7 act. The summary data of this family are presented in Table 13, the detailed data in Table 19, and the progeny test in Table 14.

TABLE 13

1. Showing segregation of progenies $M_{15\text{-}1,\ 2,\ 3,\ 6,\ \text{and}\ 19}$

	Greens	Patterns	Total
Total observed	326	88	414
Calculated 3:1 ratio	311	103	414
Deviation	15	—15	

$$\frac{\text{Dev.}}{\text{P.E.}} = \frac{15}{5.9} = 2.5$$

2. Showing segregation of progenies $M_{15\text{-}8,\ 10,\ 11,\ 12,\ 13,\ 14,\ 17,\ \text{and}\ 18}$

	Greens	Patterns	Total
Total observed	498	326	824
Calculated 9:7 ratio	464	360	824
Deviation	34	—34	

$$\frac{\text{Dev.}}{\text{P.E.}} = \frac{34}{9.6} = 3.5$$

3. Showing segregation of progenies $M_{15,\ 9,\ 15,\ \text{and}\ 16}$

	Greens	Patterns	Total
Total observed	146	183	329
Calculated 27:37 ratio	139	190	329
Deviation	7	—7	

$$\frac{\text{Dev.}}{\text{P.E.}} = .78$$

It may be seen in the above family that there is, in addition to the C_1 and C_2 factors for pattern seedlings which have been discussed, a third factor that, when recessive, produces pattern seedlings. This factor, when present with both c_1 and c_2, is shown above to produce 27:37 ratios.

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TABLE 14

Genotypic progeny test for family M15

Segregating for normal and chlorophyll pattern seedlings

Ratio	Genotypes	Observed	Calculated	Deviation
1	$C_1C_1C_2C_2C_3C_3$	0	.63	.63
2 2 2	$C_1C_1C_2C_2C_3c_3$ $C_1C_1C_2c_2C_3C_3$ $C_1c_1C_2C_2C_3C_3$	5	3.78	1.22
4 4 4	$C_1C_1C_2c_2C_3c_3$ $C_1c_1C_2C_2C_3c_3$ $C_1c_1C_2c_2C_3C_3$	8	7.56	.44
8	$C_1c_1C_2c_2C_3c_3$	4	5.04	1.04

$X^2 = 1.2650$
$P = 0.7406$

SUMMARY

1. An estimation of the amount of cross-fertilization in cotton in the field in the season of 1924 is given to be 2.46 per cent. However, the amount of this cross-fertilization varied in different plants.

2. A type of seedling which is yellow in color and contains only a small amount of chlorophyll is reported. The presence of two recessive genetic factors Y_2 and y_1 is shown to be necessary for the expression of this character.

3. The "pattern", which is another chlorophyll deficient seedling, ranges from a seedling with distinct areas devoid of chlorophyll to one which has a small amount of chlorophyll throughout the leaf. The expression of this character is shown to be responsible to one, two, and possibly three different genetic factors, i. e., 3:1, 9:7, and 27:37 ratios were found present in different and in the same families. Also there is a slight possibility that two of these factors are linked.

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APPENDIX TABLES 15 TO 19

TABLE 15

Segregation of progenies for pattern and green seedlings

1. Those progenies segregating for two factors

Data for family M6

Pedigree number	Dark greens	Light greens	Light patterns	Patterns	Approximate ratio
(1)	43	19	16	8	9:3:3:1
(3)	17	8	8	4	9:3:3:1
(4)	all green	—	—	—	pure
(5)	31	13	8	2	9:3:3:1
(6)	40	11	10	3	9:3:3:1
(7)	35	13	12	2	9:3:3:1

2. Those progenies segregating for one factor

	Dark greens	Light greens or light patterns	Approximate ratios
(8)	34	13	3:1
(10)	37	6	3:1
(14)	24	11	3.1
(19)	42	33	9:7
(20)	51	6	15:1

TABLE 16

Segregation of progenies for pattern and green seedlings

Data for family M1

Plant Number	Normal Greens	Patterns	Approximate Ratio Greens to Patterns
(1)	33	11	3:1
(2)	44	26	9:7
(4)	14	10	9:7
(5)	29	8	3:1
(6)	56	18	3:1
(10)	13	3	3:1
(12)	45	25	9:7
(13)	35	23	9:7
(14)	25	8	3:1
(17)	47	14	3:1
(19)	56	30	9:7
(20)	6	2	3:1

TABLE 17

Segregation of progenies for pattern and green seedlings

Data for family M7

Plant Number	Normal Greens	Patterns	Approximate Ratio
(1)	30	17	9:7
(3)	45	27	9:7
(4)	47	25	3:1
(5)	32	24	9:7
(6)	57	31	3:1
(9)	54	31	9:7
(10)	43	17	3:1
(11)	48	14	3:1
(13)	all green	—	
(14)	32	11	3:1
(15)	42	25	9:7
(16)	20	26	9:7
(17)	25	21	9:7

TABLE 18

Segregation of progenies for pattern and green seedlings

Data for family M10

Plant Number	Normal Greens	Patterns	Approximate Ratio
(1)	39	11	3:1
(4)	28	14	9:7
(5)	45	12	3:1
(6)	53	24	9:7
(9)	27	23	9:7
(10)	31	8	3:1
(11)	55	9	3:1
(12)	31	14	9:7
(13)	38	26	9:7
(19)	44	12	3:1
(14)	29	13	9:7
(16)	18	8	9:7
(18)	26	10	3:1
(20)	26	10	3:1

TABLE 19

Segregation of progenies for pattern and green seedlings

Data for family M15

Plant Number	Normal Greens	Patterns	Approximate Ratio
(1)	67	12	3:1
(2)	97	24	3:1
(3)	59	21	3:1
(4)	55	62	27:37
(6)	49	19	3:1
(8)	69	52	9:7
(9)	32	37	27:37
(10)	43	29	9:7
(11)	158	83	9:7
(12)	46	38	9:7
(13)	36	30	9:7
(14)	43	36	9:7
(15)	26	43	27:37
(16)	33	41	27:37
(17)	49	28	9:7
(18)	54	30	9:7
(19)	64	12	3:1