VOLUME XI APRIL, 1921 NO. 1

STUDIES OF INHERITANCE IN THE JAPANESE CONVOLVULUS. PART II.

BY B. MIYAZAWA.

(With One Coloured Plate.)

INTRODUCTION.

SINCE the culture experiments ending with 1918 have led me to certain definite conclusions in respect to the hereditary behaviour of various shades of flower-colours which appear in the F_2 generation, and which were shortly noticed in my previous paper[1], I should like to describe below the results of these experiments. In my previous article I have mentioned the fact that yellow plants never bear dark-red flowers, but recently I was able to get a yellow-leaved race which nevertheless produces dark-red flowers; and as I have conducted hybridisation experiments between such a race and each of the two original parents, the results so far obtained will be given also in this paper.

First of all, I will mention here briefly some results obtained by many investigators as regards the inheritance of flower-colours which seem to have special relations with my own studies.

Bateson and Punnett[2] reported in *Lathyrus odoratus* several cases where the flower-colour presented by neither parent appears in F_1 or in and after F_2. Saunders[3] found in *Matthiola* that certain two white-flowered individuals crossed together gave coloured F_1, and such a case was also reported by Marryat[4] and by Takezaki[5] in *Mirabilis* and Japanese *Convolvulus*, respectively. Saunders[6] obtained purple-flowered F_1 between pink and white varieties of *Salvia Horminum*, and in F_2 the ratio was

---

[1] *Journal of Genetics*, Vol. VIII. No. 1, p. 62, 1918.

[2] *Reports to the Evolution Committee of the Royal Society*. II. pp. 83—99, 1905.

[3] *L.c.* I. p. 45.

[4] *L.c.* V. p. 46.

[5] "Nippon Ikusyugakukwai Kwaihô" (*Journal of the Japanese Breeders' Association*), I. 1, Tab. V and VI. 1916.

[6] *Reports to the Evolution Committee of the Royal Society*, 1905. II. p. 50.

9 purple : 3 pink : 4 white. Tschermak[1] also got similar results in *Pisum sativum*. All these cases shew that the cooperation of the two factors is necessary for the production of anthocyanin.

The fact that the diluting or modifying factor is present in the flower of *Matthiola* was confirmed by Saunders[2]; Bateson and Punnett[3] also reported a case in *Lathyrus* that can be explained by the presence of the diluting factor.

Baur[4] found in *Antirrhinum* that zygotes heterozygous for L in the presence of D are pale magenta in flower-colour, whereas those homozygous for L are intermediate magenta in the same respect. Marryat[5] discovered in *Mirabilis* the occurrence of heterozygous forms with flower colours which may be best represented by the following formulae:

CCMM.........crimson
CcMM ....magenta
CcMm ....magenta rose
CCMm.........orange red
CCmm ....yellow
Ccmm ....pale yellow

A case where the effects of the one factor, T, are not manifested unless the other, L, is at the same time present in the zygote was studied by Wheldale[6] in *Antirrhinum*; namely, no magenta colour appears in the flower tube unless there is magenta colour in its lips.

Bateson[7] studied the relation between the colour and the shape of flower in *Lathyrus*, and found that in that having the hooded standard the colours of the standard and wings agree with each other, but in that having the erect-standard they do not.

EXPERIMENTS.

I. F_2 GENERATION.

As the characters of both parents as well as the F_1 plant are already described in Part I[8] of this paper I will not repeat them here, but as to the flower-colour of each F_2 plant, though it was described in the

---

[1] *Zeitschrift für induktive Abstammungs und Vererbungslehre*, 1912, Bd. vii. pp. 81—234.

[2] *Proceedings of the Royal Society*, Vol. lxxvii. 1905, pp. 236—238.

[3] *Reports to the Evolution Committee of the Royal Society*, 1906. III. p. 33.

[4] *Zeitschrift für induktive Abstammungs und Vererbungslehre*, 1910, Bd. iii. pp. 34—98.

[5] *Reports to the Evolution Committee of the Royal Society*, 1909. V. pp. 42—46.

[6] *Proceedings of Royal Society of London*, 1907, Vol. lxxix. B, pp. 288—305.

[7] *Journal of Genetics*, Vol. viii. No. 1, pp. 61, 62.

[8] *L.c.* pp. 61, 62.

previous paper[1], I should like to repeat it here shortly. In F_2 not only do we find flowers of white, dark-red and magenta colour, exactly similar to those of the two original parents and the F_1 plant, respectively, but also we have those of scarlet colour; and besides, in each of these colours —dark-red, magenta, and scarlet—there are three gradations of tone, sharply distinguishable from each other, which I will call *light, medium* and *deep*, respectively. (See Pl. I, figs. 1—9.)

The details of the segregation of leaf- and flower-colours in F_2 are shewn in Table I.

TABLE I.

Leaf-colour	Flower-colour	Actual numbers of individuals	Expected
Green	light magenta	164	166·500
	magenta	74	83·250
	deep magenta	72	83·250
	light scarlet	48	55·500
	scarlet	24	27·750
	deep scarlet	24	27·750
	light dark-red	111	111·000
	dark-red	69	55·500
	deep dark-red	58	55·500
	white	217	222·000
Yellow	light magenta	95	83·250
	magenta	45	41·625
	deep magenta	49	41·625
	light scarlet	32	27·750
	scarlet	14	13·875
	deep scarlet	14	13·875
	light dark-red	0	—
	dark-red	0	—
	deep dark-red	0	—
	white	74	74·000
Totals		1184	

Here it may be remarked that in the above Table the results of two reciprocal crosses as well as those of the F_2 experiments repeated in 1917 are all summed up, because I have found no essential difference among all these results.

In Table I we see that in green plants the ratio between magenta, scarlet, and dark-red is nearly equal to $3:1:2$, and that in yellow plants that between magenta and scarlet is nearly equal to $3:1$, and moreover, it will be seen that of the three gradations of the tone of each colour the ratio of light : medium : deep is $2:1:1$. In order to explain such results I have adopted the following genetic formulae for the two parents:

$$A = \mathsf{ggddBBMM},$$
$$B = \mathsf{GGDDbbmm}.$$

---

[1] *L.c.* p. 62.

The meaning of the factors is as follows:

G, the factor for green colour in the leaf.

D, that for dark-red flower-colour when the accompanying G is in homozygous condition; it produces, however, scarlet colour when G is present as Gg, or when it is altogether absent (i.e. gg) and B is also absent.

B, that for blue colour; in the presence of D its effects are not manifest when G is present as GG; it produces magenta colour both in homo- and heterozygous condition, when G is in the condition Gg or gg.

M, that for modifying the tone of flower-colour both in homo- and heterozygous condition, i.e. the *medium* grade of magenta, scarlet, or dark-red colour is produced when M is present and the plant is also homozygous for D; the *light* grade of each of these colours is produced when M is present and the plant is at the same time heterozygous for D; and finally the *deep* grade appears when M is altogether absent.

The genetic constitution of each F_1 plant is naturally GgDdBbMm, and when it is self-fertilised we expect 81 zygotes of different genetic constitutions, as is shewn in Table II. Thus we may acknowledge that my hypotheses above stated will well explain all my results. It is necessary to add here that though the meaning of the factor D is somewhat more broadened in this than in my first paper, inasmuch as not only is its action intimately bound with G but also with B, nevertheless my view in respect to the relation between green leaf and dark-red flower-colour remains quite unchanged.

II. Back-crossing.

In 1916 the back-crossing of one F_1 plant by both of the two parents, *A* or *B* was done.

1. $F_1 \times A$ (= GgDdBbMm × ggddBBMM).

The results are shewn in Table III.

TABLE III.

	Light magenta	White	Totals
Green ...	33	48	81
Yellow ...	45	38	83
Totals ...	78	86	164
Expected ...	*41* *41*	*41* *41*	

In this case, as was described in my previous paper, it will be seen that the ratios between green and yellow plants and between light magenta and white are 1 : 1, respectively; and besides, coloured flowers

TABLE II.

Genetic constitutions	Number of individuals		Flower colour	Leaf colour
GgDdBBMM	(4)	(36)	Light magenta	Green
GgDdBBMm	(8)			
GgDdBbMM	(8)			
GgDdBbMm	(16)			
GgDDBBMM	(2)	(18)	Magenta	
GgDDBbMM	(4)			
GgDDBBMm	(4)			
GgDDBbMm	(8)			
GgDDBBmm	(2)	(18)	Deep magenta	
GgDDBbmm	(4)			
GgDdBBmm	(4)			
GgDdBbmm	(8)			
GgDdbbMM	(4)	(12)	Light scarlet	
GgDdbbMm	(8)			
GgDDbbMM	(2)	(6)	Scarlet	
GgDDbbMm	(4)			
GgDDbbmm	(2)	(6)	Deep scarlet	
GgDdbbmm	(4)			
GGDdBbMM	(4)	(24)	Light dark-red	
GGDdBBMm	(4)			
GGDdBbMm	(8)			
GGDdbbMM	(2)			
GGDdBBMM	(2)			
GGDdbbMm	(4)			
GGDDBBMM	(1)	(12)	Dark-red	
GGDDBbMM	(2)			
GGDDBBMm	(2)			
GGDDbbMM	(1)			
GGDDBbMm	(4)			
GGDDbbMm	(2)			
GGDDBBmm	(1)	(12)	Deep dark-red	
GGDDbbmm	(1)			
GGDDBbmm	(2)			
GGDdBBmm	(2)			
GGDdbbmm	(2)			
GGDdBbmm	(4)			
GGddBBMM	(1)	(48)	White	
GGddbbMM	(1)			
GGddBBmm	(1)			
GGddBbMM	(2)			
GGddBBMm	(2)			
GGddBbMm	(4)			
GGddBbmm	(2)			
GGddbbMm	(2)			
GGddbbmm	(1)			
GgddBBMM	(2)			
GgddBBMm	(4)			
GgddBbMM	(4)			
GgddBBmm	(2)			
GgddbbMM	(2)			
GgddBbMm	(8)			
GgddBbmm	(4)			
GgddbbMm	(4)			
Ggddbbmm	(2)			
ggDdBBMM	(2)	(18)	Light magenta	Yellow
ggDdBBMm	(4)			
ggDdBbMM	(4)			
ggDdBbMm	(8)			
ggDDBBMM	(1)	(9)	Magenta	
ggDDBbMM	(2)			
ggDDBBMm	(2)			
ggDDBbMm	(4)			
ggDDBBmm	(1)	(9)	Deep magenta	
ggDDBbmm	(2)			
ggDdBBmm	(2)			
ggDdBbmm	(4)			
ggDdbbMM	(2)	(6)	Light scarlet	
ggDdbbMm	(4)			
ggDDbbMM	(1)	(3)	Scarlet	
ggDDbbMm	(2)			
ggDDbbmm	(1)	(3)	Deep scarlet	
ggDdbbmm	(2)			
ggddBBMM	(1)	(16)	White	
ggddBbMM	(2)			
ggddBBMm	(2)			
ggddBBmm	(1)			
ggddbbMM	(1)			
ggddBbMm	(4)			
ggddBbmm	(2)			
ggddbbMm	(2)			
ggddbbmm	(1)			

are light magenta exclusively. The reason for this will readily be seen when we compare the genetic constitutions of the F_1 and A plants.

2. $F_1 \times B$ (= GgDdBbMm × GGDDbbmm).

The results are shewn in Table IV.

TABLE IV.

	Light magenta	Magenta	Deep magenta	Light scarlet	Scarlet	Deep scarlet	Light dark-red	Dark-red	Deep dark-red	White	Totals
Green	8	6	12	4	7	9	9	11	15	0	81
Yellow	0	0	0	0	0	0	0	0	0	0	0
Expected	*5·063*	*5·063*	*10·125*	*5·063*	*5·063*	*10·125*	*10·125*	*10·125*	*20·250*	*0*	
	0	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	

In this case all plants have green leaves and we find magenta, scarlet, and dark-red flowers in all their respective three tones. If we add together individuals of each colour belonging to the same tone it will be seen that the ratio magenta : scarlet : dark-red is 1 : 1 : 2, and in each colour there are two plants of deep tone for each one of the two other tones. Here again the facts are clearly in accordance with hypotheses put forward.

III. F_3, F_4, AND F_5 GENERATIONS, ETC.

I have made a series of breeding experiments on various families in F_3, F_4, and F_5; moreover, various crosses were made among the offspring of the hybrids both with one another and with the original parents, the offspring in each case being grown on. All these experiments have fully borne out my interpretation above given, and since I have never encountered any contradictory case, I will not describe here details of all these results, but simply some few selected examples.

1. *Green plant with magenta flower.*

The results are shewn in Table V.

TABLE V.

		Magenta	Scarlet	Dark-red	Totals	
F_3, No. 31	green	40	8	32	80	99
	yellow	12	7	0	19	
F_4, No. 31—1	green	22	7	14	43	58
	yellow	13	2	0	15	
Totals	green	62	15	46	123	157
	yellow	25	9	0	34	
Expected	...	*58·875*	*19·625*	*39·250*		
		29·437	*9·813*	*0*		

It is apparent from the above Table that in green plants the ratio magenta : scarlet : dark-red is 6 : 2 : 4, and that in yellow plants the ratio magenta : scarlet is 3 : 1, so that we must consider that the genetic constitution of the plant used is **GgDDBbMM**.

2. *Green plant with deep magenta flower.*

The results are indicated in Table VI.

TABLE VI.

		Deep magenta	Deep dark-red	Totals	
No. 9—23	green	51	23	74	95
	yellow	21	0	21	
Expected	green	*47·50*	*23·75*		
	yellow	*23·75*	*0*		

It will be seen from the above Table that the ratio green, deep magenta : green, deep dark-red : yellow, deep magenta is 2 : 1 : 1. Thus we may consider the genetic constitution of the plant used to have been **GgDDBBmm**.

3. *Green plant with light scarlet flower.*

The results are as follows:

TABLE VII.

		Light scarlet	Scarlet	Deep scarlet	Light dark-red	Dark-red	Deep dark-red	White	Totals	
No. 60	green	20	10	11	7	6	4	20	78	101
	yellow	7	4	4	0	0	0	8	23	
Expected		*18·938*	*9·469*	*9·469*	*9·469*	*4·734*	*4·734*	*18·938*		
		9·469	*4·734*	*4·734*	*0*	*0*	*0*	*6·313*		

From the above Table we see that in green plants light scarlet : scarlet : deep scarlet : light dark-red : dark-red : deep dark-red : white are in the ratio 12 : 6 : 6 : 6 : 3 : 3 : 12, and in yellow plants light scarlet : scarlet : deep scarlet : white are in the ratio 6 : 3 : 3 : 4. Thus the genetic constitution of the plant used must have been **GgDdbbMm**.

4. *Green plant with scarlet flower.*

The results are shewn in Table VIII.

TABLE VIII.

		Scarlet	Deep scarlet	Dark-red	Deep dark-red	Totals	
$F_1 \times B$, No. 13	green	41	13	18	8	80	105
	yellow	20	5	0	0	25	
Expected		*39·375*	*13·125*	*19·688*	*6·563*		
		19·688	*6·563*	*0*	*0*		

This Table shews that the ratio scarlet : deep scarlet : dark-red : deep dark-red is 6 : 2 : 3 : 1 in green plants and also, that scarlet : deep scarlet is 3 : 1 in yellow plants. Accordingly the genetic constitution of the plant used must have been **GgDDbbMm**.

5. *Green plant with light dark-red flower.*

The results are indicated in Table IX.

TABLE IX.

	Light dark-red	Dark-red	White	Totals
No. 14 ...	45	20	14	79
,, 55 ...	28	9	11	48
,, 14—2 ...	48	33	25	106
,, 19 (1918)	65	38	36	139
Totals ...	186	100	86	372
Expected ...	*186·00*	*93·00*	*93·00*	

From the above Table we see that the ratio light dark-red : dark-red : white is 2 : 1 : 1. Let us now consider what should be the genetic constitution of the plant used. From the explanation of the results in F_2 (Table II) we know that there should be six different genetic constitutions in plants with light dark-red flowers. But our hypothesis assumes that when **G** is in homozygous condition in the presence of **D**, the effect of **B** is not manifest, so that in this case, the result is quite the same, whether **B** is present as **BB**, **Bb** or **bb**. Consequently, the genetic constitution of the four families above mentioned must correspond to either one of **GGDdBBMM**, **GGDdBbMM** or **GGDdbbMM**; and in order to determine which of these three is the actual one, the hybridisation experiments with other families would be necessary.

6. *Yellow plant with light magenta flower.*

The results are indicated in Table X.

TABLE X.

	Light magenta	Magenta	Light scarlet	Scarlet	White	Totals
No. 39—1...	47	26	19	6	40	138
Expected ...	*51·750*	*25·875*	*17·250*	*8·625*	*34·500*	

From the above Table it is quite evident that the ratio light magenta : magenta : light scarlet : scarlet : white is 6 : 3 : 2 : 1 : 4, so that the genetic constitution of the plant used must have been **ggDdBbMM**.

7. *Yellow plant with magenta flower.*

The results are shewn in Table XI.

TABLE XI.

	Magenta	Deep magenta	Scarlet	Deep scarlet	Totals
No. 39—7 ...	64	22	22	10	118
Expected ...	*66·375*	*22·125*	*22·125*	*7·375*	

In the above Table we see that the ratio magenta : deep magenta : scarlet : deep scarlet is 9 : 3 : 3 : 1. Thus the genetic constitution of the plant used must have been **ggDDBbMm**.

8. *Yellow plant with light scarlet flower.*

The results are shewn in Table XII.

TABLE XII.

	Light scarlet	Scarlet	White	Totals
No. 22—4— 6 ...	32	14	15	61
,, 22—4—10 ...	17	14	8	39
Totals	49	28	23	100
Expected ...	*50*	*25*	*25*	

Thus the ratio light scarlet : scarlet : white is 2 : 1 : 1, so that the genetic constitution of the plants used must have been **ggDdbbMM**.

9. *Yellow plants with dark-red flowers.*

As was reported in my previous paper[1], I found in F_4 a family (44—6) which, in spite of the fact that it segregates into green and yellow plants, yet breeds true to dark-red flowers; evidently there must exist some special reason for this fact, and the experimental results conducted on this family in F_5 are as follows:

TABLE XIII.

	Leaf colour in F_4	Leaf colour in F_5	Dark-red
No. 44—6— 2	Yellow	Yellow	81
,, — 4	,,	,,	25
,, —10	Green	Green	40
,, — 7	,,	Green	22
		Yellow	6

The above Table shews that all the families have dark-red flowers in spite of their yellow leaf-colour. What then, we may ask, is the cause which has led to such contradictory results? Now let us consider in

---

[1] *Journal of Genetics*, Vol. VIII. No. 1, p. 73.

detail the ancestors of these families. The seeds of these families were taken from the individuals which segregated in the following manner in F_3:

		Scarlet	Deep scarlet	Dark-red	Deep dark-red	Totals	
No. 44	green	13	9	9	8	39	50
	yellow	6	5	0	0	11	

The family 44—6 was the offspring derived by self-fertilisation from a plant having green leaf and dark-red flower. Consequently if the hereditary behaviour of these characters were normal we should have in the offspring leaves which are constantly green and flowers which are either constantly dark-red or will segregate into dark-red and deep dark-red. The results, however, have shewn that notwithstanding the fact that the flower-colour is constantly dark-red the leaf-colour segregates into 3 green and 1 yellow. So that it may be considered that there occurred some permanent variation among the factor or factors in the F_3 plant used for self-fertilisation. But we cannot decide how and where such change has occurred, and any hypothesis on this point would be useless unless founded on the facts actually obtained, so that this case will remain the subject of my future study.

IV. HYBRIDS BETWEEN *A* OR *B* WITH A RACE *C* WHICH HAS YELLOW LEAF AND DEEP DARK-RED FLOWER.

In all cases described till now there were found no yellow plants with dark-red flowers, except the case given above. Such a plant, however, is found among certain races of Japanese *Convolvulus*, and it seems to have been in cultivation more than 60 years ago, as it is described in a book entitled *Santo Ittyô* published in 1854, in which many coloured figures are found. My material is characterised by having the "hukurin" part on the margin of the flower. Although I have described the flower-colour of this race as deep dark-red, I found that certain differences are discernible between *B* and *C*, inasmuch as the colour of the latter is a little darker than that of the former. They are, however, so similar to each other that this slight difference would not be noticeable without direct comparison.

1. *A* × *C* *and* *C* × *A*.

a. F_1 *generation.*

In both reciprocal crosses I obtained exactly the same results, the leaf being yellow and the flower light magenta. The "hukurin" appeared in quite the same manner as in the parent *C*.

b. F_2 *generation.*

All the individuals had yellow leaves. As in the case of $A \times B$ we obtained here also flowers of magenta, scarlet, and dark-red colour, and moreover there were found the three usual tones in each. All plants with coloured flowers had the "hukurin" on the corolla. It must be said that all the tones of flower-colour in $C \times A$ are somewhat different from those of F_2 plants in $A \times B$, and moreover, that the magenta and scarlet colour are slightly more blue-tinged in the former than in the latter.

The results of both reciprocal hybridisation are shewn collectively in Table XIV.

TABLE XIV.

	$A \times C$	$A \times C$	Totals	Expected
Light magenta ...	33	36	69	*69·563*
Magenta... ...	16	20	36	*34·782*
Deep magenta ...	14	23	37	*34·782*
Light scarlet ...	13	16	29	*34·782*
Scarlet	7	10	17	*17·391*
Deep scarlet ...	7	9	16	*17·391*
Light dark-red ...	15	19	34	*34·782*
Dark-red	11	11	22	*17·391*
Deep dark-red ...	8	9	17	*17·391*
White	44	50	94	*92·750*
Totals ...	168	203	371	

It will be readily seen from the above Table that the results are altogether similar to those of $A \times B$.

2. $B \times C$.

a. F_1 *generation.*

F_1 plants had green leaves with deep dark-red flowers.

b. F_2 *generation.*

The flower of all F_2 plants was deep dark-red, and the leaf-colour segregated into green and yellow. As previously mentioned, there was a little difference between the flower-colours of B and C, and this difference appeared in F_2, but as it was extremely difficult to distinguish them clearly I did not undertake to do this work. I will only mention here, however, that also in yellow plants the flower-colour similar to that of B parent has been observed. The results are indicated in Table XV.

In the above Table we see that the ratio green, "hukurin" : green, fully-coloured : yellow, "hukurin" : yellow, fully-coloured is 9 : 3 : 3 : 1, so that it may be seen that the leaf-colour and the "hukurin" are inherited in a simple Mendelian fashion.

TABLE XV.

		Number 1	Number 2	Totals	Expected
Green	white-margined ...	48	31	79	75·938
	fully-coloured ...	18	9	27	25·313
Yellow	white-margined ...	14	7	21	25·313
	fully-coloured ...	6	2	8	8·438
Totals		86	49	135	

From the results of $A \times C$, $C \times A$, and $B \times C$ it is clear that the genetic constitution of the C parent is **ggDDbbmm** with respect to the leaf- and flower-colour. Yet if we will speak more strictly there may exist some differences as regards the factor **D** between B and C, but I did not undertake to study these differences.

It is quite clear from the above results that C has a factor to produce the "hukurin" on the corolla; moreover that this factor is present in A but not in B has been fully confirmed.

V. SOME FACTS OBSERVED DURING THE EXPERIMENTS.

1. *Relation between the colour of flowers and that of other parts of plant.*

Many observations have already been made by several authors as regards the relation between the colours of flowers and those of other parts of plant. The phenomenon most commonly known is that where positive relations exist between them. Gregory[1] observed in *Primula sinensis* that anthocyanin may be entirely absent when the stem is green and that pale flower-colour is associated with faint colour in young leaves as well as green or faintly coloured stem; besides, he has discovered the following associations: deep flower-colour and deep stem-colour, true red flower-colour and true red stem, blue flower-colour and blue stem. Nohara[2] observed in his study of inheritance on *Oxalis corniculata* that the purple colour in the eye of the corolla and in the leaf are associated to each other, but the leaf-purple can appear without being associated with the eye purple. I[3] have reported in the garden varieties of *Rhododendron obtusum, Rh. ledifolium* var. *purpureum,* and *Rh. indicum* var. *macranthum* which are cultivated in Japan, that the more intense the

---

[1] *Journal of Genetics*, 1911, Vol. I. pp. 73—132.

[2] *Journal of College of Agriculture*, Tôkyô, 1915, Vol. VI. pp. 165—181.

[3] *Journal of the Scientific Agricultural Society*, Tôkyô, 1914, No. 145, pp. 1—6.

reddish-brown colour of winter leaves are, the deeper the flower-colour is; besides I have reported that white flower-colour is associated with green leaf, and striated flower with striated leaf.

The above statements shew that the colours of flower and leaf or stem are due to one and the same factor. There are some cases, however, where the colour of flower and that of other plant-organs seem not to be determined by one factor. Shull[1] found in the hybrids between *Oenothera rubricalyx* and *rubrinervis* and those between *rubricalyx* and *Lamarckiana* that pigmented buds of *rubricalyx* is invariably associated with a low degree of pigmentation in stems and rosettes. Besides these, many other examples were reported in *Primula sinensis*, *Helianthus* and *Lathyrus*, etc.

In the Japanese *Convolvulus* white flowers may be associated with green or yellow stem, and coloured flowers with pigmented stem. In my experiments the stem-colours in plants with deep-coloured flowers were found to be deeper than in those of light-coloured individuals, and moreover the stems of plants with dark-red flowers were dark-reddish-brown and those of scarlet flowers were reddish-purple. But I could not discern the differences of stem colours between plants with magenta and those with scarlet flowers. Thus the relation between the colours of stem and flower is similar to what we see in *Primula sinensis.*

2. *On streaked flowers.*

Though there are many investigations on the inheritance of streaked flowers in *Antirrhinum, Mirabilis*, etc., I will mention here simply the facts observed in Japanese *Convolvulus.* In and after the F_2 generation I have often observed that just one half of a petal to the throat produced a colour entirely different from that in other parts. Such phenomenon did not occur in all flowers of a plant but only in one or two out of fifty or more. Thus I have seen a light magenta part in a light scarlet flower, a magenta part in a scarlet flower, and a deep magenta part in a deep dark-red flower. These are the instances where the dominant colour was produced in a recessive coloured flower, though I have once seen a deep scarlet part in a deep magenta flower, i.e. recessive colour in dominant coloured flower.

Emerson[2] studied the occurrence of anomalous seeds of maize as regards their pigmentation. In one case, the seed was half colourless

---

[1] *Journal of Genetics*, 1914, Vol. IV. pp. 83—102.

[2] *Zeitschrift für induktive Abstammungs und Vererbungslehre*, 1915, Bd. XIV. pp. 241—259.

and half purple; in the other, half purple and half red. His opinion on the occurrence of this phenomenon is that it is due to a somatic mutation, that is a change in genetic constitution rather than a segregation of genetic factors, and this somatic mutation may be a gain of at least one new factor, the loss of a factor, or the permanent modification of a factor. Moreover he brings against the segregation hypothesis the following considerations. "If a dominant character appears as a bud sport, in material known to be homozygous with respect to a recessive character that is allelomorphic to the dominant character in question, it seems clear that a somatic mutation is the responsible agent....It would be interesting to know whether recessive bud sports actually occur much more frequently in heterozygous than in homozygous material. If this is found not to be the case, it will have an important bearing upon the problem of whether bud sports are mutations or segregations, for the latter would occur only in heterozygous material."

Above we have described three cases of Japanese *Convolvulus* where the dominant character has arisen in material known to have the recessive characters. Accordingly it is impossible to consider this phenomenon merely due to the segregation of factors, but it will be necessary to think that there occurred some change in the somatic cells which have had recessive characters. I did not cultivate the offspring of the plant which produced a deep scarlet coloured part in a deep magenta coloured flower, so that I cannot decide whether the original colour was in a homozygous or a heterozygous condition. If in the latter condition we may consider the phenomenon due either to the segregation of factors or to somatic mutation, but if in homozygous condition the latter would seem to be the real cause of the phenomenon.

3. *The relation between leaf-colour and the growth habit of plant-body.*

The parent *B*, which has green leaves, grows vigorously. It has a big and long stem with long internodes, and side branches appear at the fifth or sixth leaf axil from the base. *A* on the other hand has a slender stem with side branches appearing at the second or third leaf-axil and flowers opening earlier than *B*. The F_1 plant has characters similar to those of *B*, at least as regards the above stated points. In the F_2 generation also these characters were found to be associated with the leaf-colour, though I did not undertake to measure. It is quite clear that the weak growth of yellow-plant is due to small amount of green pigment in them.

JOURNAL OF GENETICS, VOL. XI. NO. 1

PLATE I

Del. N. Midusima

Cambridge University Press

SUMMARY.

1. The light magenta colour in F_1 is produced when both G and D are in heterozygous condition; and the bluing-factor B and the modifying factor M are brought in from the parent *A*.

2. Reciprocal hybrids are similar to each other in all respects.

3. D produces dark-red colours when G is present in a homozygous condition, but it produces red-colours (magenta and scarlet) when G is present in a heterozygous condition or altogether absent. Such an interrelation between G and D was found only in the hybrids between *A* and *B*, and it does not exist in other hybrids, though *C*, for instance, has colours closely related to those of *B*.

4. The fact that D has such a character may be seen closely from the results in which all three families of the offspring of (10—1) × (16—9) which is green, white and yellow, deep scarlet, respectively, produced dark-red colours.

5. The effects of B are not manifested in the individuals which are in a homozygous condition with respect to G.

6. The magenta colour appears in plants which have the constitution DB, either Gg or gg being present at the same time. On the contrary, the scarlet colour appears only in plants which are in the condition Db.

7. The white colour appears in the individuals when D is altogether absent, and then G, B, and M may be in any condition. So that there are various genetic constitutions among white-flowered plants.

8. The interrelations between D and M are as follows:

DdM ....light colour
DDM ....medium colour

$$\left.\begin{array}{l}\text{DDmm}\\ \text{Ddmm}\end{array}\right\}\text{.........deep colour}$$

9. The magenta colour is dominant over both scarlet and dark-red, and scarlet is dominant over dark-red.

10. There may exist homozygous plants, at least with respect to flower-colour, with medium and deep tones of magenta, scarlet, and dark-red; but we could find no individuals with light tones of each colour.

EXPLANATION OF PLATE I.

Figs. 1, 2, 3. Light, medium, and deep magenta.
Figs. 4, 5, 6. ,, ,, ,, scarlet.
Figs. 7, 8, 9. ,, ,, ,, dark-red.