A PRELIMINARY NOTE ON INHERITANCE IN CASTORS

BY

G. B. PATWARDHAN, B. SC.,

Ag. Economic Botanist to Government of Bombay, Agricultural College, Poona.

The Botany Department of the Poona Agricultural College has been doing some selection work in Castors with a view to isolate highly yielding strains containing also a high percentage of oil.

As a side show to the work and for the benefit of the students of Plant Breeding at the College, 28 crosses were made in the years 1927 and 1928. In spite of the absence of full equipment of land and "sinews of war" required for a thorough investigation of the problems involved, some attempts were made to study the inheritance of certain characters and the results obtained, it is hoped, will justify them.

The material presented in this paper is the product of some part time work of the writer. The research recorded therein is inevitably incomplete in some cases and in consequence any conclusions mentioned are tentative. Besides Harland's and Peat's articles cited later had unfortunately not come to the notice of the writer before he started the above research.

As I am not likely to continue the research any further, due to my impending retirement from service and since no one else here may take up this research at the point left by me, I think that it might go in print for what it is worth instead of remaining locked up in the records here. But my main justification for offering the material for publication is that it contains some interesting facts which may, I hope, stimulate other investigators to verify them and to proceed further.

Twenty-eight crosses were made in 1927-28.

Out of these ten involved the testing of stem colour ; six of these failed to set seed and two of them *i.e.*, cross Nos. 11 and 12, gave a splitting in F_1. Further testing of these could not be undertaken on account of local limitations. The remaining two crosses Nos. 1 and 6-A are reported in this paper.

Eight crosses involved bloom characters ; of these three failed ; one which was successful was not taken up further. Four are reported below.

Eight crosses concerned the colour of fruit, four of which failed; in one cross and its reciprocal, Nos. 13 and 14, the purity of one parent was doubted and it was, therefore, dropped. One cross, No. 21, was not used for further test. One *i.e.* No. 17 is reported here.

Two crosses involved the presence of spines. One failed and the other is reported in this paper.

It should also be noted here that, for the purpose of making the crosses, such plants only as had the greatest amount of resemblance in their external morphological features between themselves were selected as parents, differing only in the single pair of characters under study.

I. Inheritance of Spines.

Cross No. 20 :—♀. 15 B. 6.5 spineless X ♂. 12. B. 5. 4 Spiny.

The parents were pure in the two previously selfed generations and were grown from selfed seed in 1927. The cross was made in January 1928. Both parents were exactly alike in the morphological characters of stem, leaves and bloom differing in spines only. The F_1 seeds were sown in 1929, giving thirteen F_1 plants. All showed intermediate dominance of spininess in their sparse distribution on the Capsule. (Plate 9). This confirms Harland's (1) and Peat's (2) results. No sowing has yet been made for getting F_2 progeny.

II. Inheritance of Bloom.

(*a*) Cross No. 23: —♀. 7 C. 1–1–5. bloomy X ♂. 7c–3–6–3 bloomless.

Parents were quite alike in other respects and pure for the bloom character in the two previous selfed generations.

(*b*) Cross No. 24 :—This is a reciprocal cross of No. 23.

Crossing was done in December 1928. F_1 plants were grown in July, 1929. There were 15 and 11 plants of the two crosses respectively. The quantity of bloom on the F_1 plants was less than on the bloomy parents (Fig. 4) and thus F_1 individuals of both crosses were exactly alike. Thus the bloominess is partially dominant, confirming Harland's (1) experiments. It may be noted here that the bloomy parent had single bloom as defined by Peat (2).

At this stage the meaning of the different kinds of bloom may be explained. Peat (2) defines :—

Single Bloom = Presence of bloom on stem, petiole and peduncle.

Double Bloom = Presence of bloom on stem, petiole, peduncle and lower surface of leaf.

The writer discovered varieties with bloom on stem, petiole, peduncle and both surfaces of leaves; this condition is designated as Treble bloom.

(*c*) Cross No. 25 :—♀.51 C. 2–6–4 bloomy X ♂. 30A–1–5 bloomless.

The ♂ parent was pure in two previous generations and so was the ♀ parent in three previous generations. The cross was made in December, 1928. Thirteen F_1 plants* were grown in 1929; all these had bloom but the quantity on the stem on the date of first observation, *i.e.*, early in January, 1930, was as much as that on the mother. A further critical examination on 31-1-1930, when the plants had advanced better in growth than before, showed that seven plants had double bloom and six had treble bloom. The ♀ parent had treble bloom.

In this cross, therefore, we find bloominess partially dominant as indicated by the appearance of double bloom plants in F_1 but six of the F_1 plants had treble bloom. This may be due to the natural selfing of some flowers appearing on the peduncle subsequent to the bagging after the female flowers had been crossed.

(*d*) Cross No. 26 :—This is reciprocal of cross No. 25.

The fourteen F_1 plants grown had all double bloom, the masculine parents having treble bloom. Here also the bloom is partial in F_1.

The results of the crosses Nos. 23, 24, 25 and 26 showed (1) that the bloom character is intermediate in F_1 and (2) that treble bloom is dominant to double bloom and single bloom to no bloom.

III. Inheritance of Colour of Capsules.

(*a*) Cross No. 17 :—♀ 33.B. 3-1 fruit green X ♂ 17.B-2-1. fruit bright pink.

Both the parents were pure in two previous generations as to the fruit colour and were quite alike in their bloomy red stem, green leaves with light mauve bloom and vigorous growth. The cross was made in December, 1927. The F_1 plants showed light pink colour in 1928.

The F_2 plants in 1929 showed splitting into red (bright pink) pink and green progeny. The actual distribution in the field was :—

Line	Green	Red	Pink	Undetermined: and late	Undetermined: and early	Total
1	20	5	2	3	0	30
2	21	6	3	1	0	31
3	19	1	3	4	1	28
4	17	2	8	5	0	32
5	11	0	4	1	1	17
Total	88	14	20	14	2	138

* These plants were not sown in July, 1929, along with others including parent plants. They happened to be sown late in the season *i.e.*, in October. At the time of final observation, *i.e.* on 31st January, 1930, they were only 2½ feet high while the ones sown earlier were 12 to 15 feet high. The late sown plants did not produce any flowers till the usual time of removal of crops in May, 1930.

The following statement shows the numbers and the goodness of fit. The plants with pink and bright pink capsules are included in one class as they cannot be distinctly segregated by normal eye observation and the undetermined ones are not taken into consideration.

Statement showing goodness of fit in the Mendelian experiment :—

Classes.	Observed frequencies.	Observed ratio.	Expected ratio.	Probable error.	Deviation.	Remarks.
Green ...	88	2.88	3	+ 101	0.12	
Bright pink and pink together.	34	1.11	1	+ 101	0.11	

Since the deviations are almost equal to the probable error they are not significant. Green is dominant to absence of green (pink) in the capsule. Confirmation by back crosses is necessary.

It might be noted here that in the field there were 16 more F_2 plants, classed as undetermined in the above first statement. Out of the sixteen, two flowered very early; they missed being observed for colour. The remaining fourteen have not yet (3–5–1930) flowered. Since the green ones have been all along very late in flowering, the fourteen can be safely classed as green ones. Thus the proportion of green to red and pink is 102 to 34 exactly 3 : 1. If the two missed ones are taken in the red class, as they might be, on account of the observed early fruiting character of the coloured varieties, still the proportion is not vitiated.

(*b*) Cross No. 21 :—♀ No. 33B. 3·2 capsule green X ♂ No. 17B. 2-1 capsule bright pink.

The parents were similar in all other respects such as red stem, bloom, green leaves and a general mauve appearance of the whole plants due to the nature of the bloom.

The cross was made in January 1928. In the growing season of 1928, the F_1 and the parents from selfed seed were grown. The parents were true to fruit colour and the F_1 plants gave pink coloured fruits. F_2 plants were not raised in 1929.

In these two crosses, pink colour is seen in F_1 but in the F_2 of cross 17, the green colour presents dominance very significantly and therefore determination of allelomorphs is difficult.

It is necessary to make reciprocal and back crosses to elucidate the points of difficulty.

IV. Inheritance of Stem Colour.

(*a*) Cross No. 1 :—♀ No. 30A. 1-5 Stem mineral green X ♂ 6B. 1-4 stem blackish red purple.

The ♀ plant had leaves, stems, branches, petioles, young leaves and all other parts green and no bloom at all. The inflorescence was greenish yellow, long and fruit same colour ; plant tall, vigorous and late flowering.

The ♂ plants had leaves, stems, branches, petioles, young leaves and all other parts dark red or purple and no bloom anywhere : inflorescence and fruit dark ; plant short, weak and early flowering.

The parents were selfed in the two previous generations. Crossing was done in December, 1927 and seeds gathered in March, 1928. The F_1 plants grown were 16, all having red stems and petiole, and green leaves. The colour character was intermediate. The F_2 plants were grown in 1929. The colour of the stem was the principal character studied. All the plants could be grouped into 11 classes. The grouping was made by the writer and confirmed by independent observation by Mr. D. V. Narayanayya, Assistant Economic Botanist. The grouping is described in the table.

Table showing classes of F_2 plants of Cross I.

Class	No. of plants in class.	Stem colour as in Ridgeway.*	† Plate No.	Description.
I	10	Blackish-red-purple. Plate 12.	1	Stem and leaf colour like ♂ parent; has more number of green leaves than the ♂; fruits not dark like ♂ parent.
II	9	Pomegranate purple. Plate 12.	2	Stem very bright red with very faint green longitudinal lines; leaves green, fruit green.
III	39	Diamine brown. Plate 13.	3	Plants like Class II but slightly less bright in stem colour, green longitudinal lines a little less marked, fruits green.
IV	14	Hesian brown. Plate 13.	4	Plants like Class III in stem colour but with many more green lines and general colour of stem a bit yellowish or greenish; fruits greenish yellow turning pink later.
V	2	Pansy purple. Plate 12.	5	Plants like Class III in stem colour and lines on it but the stem colour is much brighter. Classes III and V may be put in one class.
VI	19	Not identifiable with any plate.	6	Stem pink with many close pale green lines. The stem looks brown-pink or yellowish tinged.
VII	23	...	...	Plants like Class VI but stems are more bright red.
VIII	1	...	...	Plants like Class VII but with dark pink fruits.
IX	27	Mineral green. Plate XVIII.	...	Whole plant green with green fruits and not even a tinge of red anywhere. This is like ♀ parent except as to colour of fruit.
X	12	Mineral green. Plate XVIII.	7	Exactly like ♀ with yellow fruits. Stem colour green.
XI	26	Black-red-purple. Plate XII.	8	True like ♂ parent in stem colour, etc.

N.B.—Plants like ♀ parent are in Classes IX and X totalling 39 (green). Plants like ♂ parent are in Classes I and XI totalling 36. The rest showing varying degree of intermediateness in colour of stem numbered 107.

* The plates referred to in this column are Ridgeway's "Color Standards and Nomenclature" *vide* No. 3 in literature cited.

† Coloured plates are not reproduced here.

All the plants can be divided as to colour of stems into two classes, i.e. :—

I. No colour or Mineral green as per plate No. 18 in Ridgeway (3).

II. All others showing presence of several gradations of red colour such as rose, Mahogany, carmine, amaranth purple, pomegranate purple, etc., and culminating into Blackish red purple as in plate No. 12 in Ridgeway (3). On this basis we get the following statement showing the goodness of fit. It is very difficult to segregate correctly stems of numerous shades and tinges of colour which were seen amongst the plants of this F_2 generation. Nor could Harland's (1) Mahogany, Rose, Carmine tinged, etc., could be separately appreciated.

Tabular Statement of Cross I F_2 generation.

Colour of stem.	Observed frequencies.	Observed ratio.	Expected ratio.	Probable error.	Deviation.
Presence of colour.	143	3.14	3	±.10	.14
Green or no colour.	39	0.85	1	±.08	.15

Since the deviations are less than 3 or 4 times the probable error, they are not significant.

The same F_2 plants were grouped into three classes namely as those coloured like males, like females and the rest, the statement of fit would then be :—

Colour of stem.	Observed frequencies	Observed ratio.	Expected ratio.	Probable error	Deviation.
Purple (like males).	36	.79	1	±.0878	·21
Green (like females).	39	.85	1	±.0·78	.15
Rest (intermediate).	107	2.35	2	±.1011	.35

Here the first two deviations are less than 3 times the probable error while in the third it is less than 4 times the probable error. Therefore, the deviations are not significant. Hence the 1 : 1 : 2

ratio stands confirmed. The colour in the plates may be assumed to be due to the presence of the basic Anthocynin factor A, in the presence of which different gradations of colour show up and lack of it gives green colour.

(*b*) Cross 6A:— ♀ No. 31C. 5–1 stem green X ♂ No. 6C. 5-6 stem, purple (blackish-red-purple).

The parents were exactly similar to those in cross No. 1, in all respects mentioned in the description of that cross. The cross was made in December, 1927. Seeds were sown in the season of 1928. There were 8 F_1 plants whose stems were red i.e. the colour of stem was intermediate.

F_2 plants were grown in the year 1929. The plants were divided into 9 classes according to the colouring of stem :—

Description of the plants of the classes :—

Class.	Frequency.	Description.
I	6	Plants exactly like the ♂ parent, very black or dark red stem, dark leaves and fruits.
II	10	Like class I in colour of stem and leaves but with fewer dark red leaves, and fruits less dark than those in Class I. This is nearest the ♂ parent. So far as the stem colour character is concerned this must be taken in Class I.
III	8	Stem colour slightly black than in Class II; straight or erect stem. Many leaves coloured red.
IV	3	Like Class III, in stem colour but leaves appear more or less mauve colour.
V	30	Stem red, branching, all leaves green.
VI	29	Stem red with faint green broad lines on young stems and with dark green lines on other stems, leaves all green.
VII	2	Stem very bright red with green leaves, stem more bright than in class VI.
VIII	16	Exactly like the ♂ parent.
IX	7	Stem quite like the ♂ parent.
	111	

The plants were allotted to the different classes by the writer and the distribution was confirmed by Mr. D. V. Narayanayya by independent inspection of the plants.

Here we find 23 plants like the ♀ and 16 plants like the ♂ parent and the rest 72 showing gradations. Taking all the coloured plants in one class and the green ones in another, we find the following proportion and the goodness of fit. This grouping is very accurate as there was no chance of a full green plant being put in the coloured class.

Colour of stem.	Observed frequency.	Calculated ratio.	Expected ratio.	Probable error.	Deviation.
Coloured ...	88	3.17	3	±.107	.17
Green ...	23	0.83	1	±.107	.17

Here also the deviations are less than 3 to 4 times the probable error and therefore are not significant. Hence the mendelian ratio stands, colour being dominant to no colour or green.

If we were to classify the plants in the two parental classes and a third class to include the rest, the statement stands as follows :—

Colour of stem.	Frequencies.	Calculated ratio.	Expected ratio.	Probable error.	Deviation.	Remarks.
Colour (purple).	16	.50	1	±.107	.50	Deviation more than 4 times the probable error.
Green (no colour).	23	.83	1	±.107	.17	Deviation less than 4 times the probable error.
All intermediate colours.	72	2.59	2	±.127	.59	In this case the deviation is more than 4 times the probable error and is therefore significant

Fig. 1.
Class X. Female Parent of Cross I

Fig. 2.
Class XI. Male Parent of Cross I

Fig. 3.
Cross 20. Spineless, Spiny and Sparsely Spiny fruits of Parents, F1 plants respectively

Fig. 4.
Cross 23. Bloomy, Bloomless and Sparsely bloom stems of Parents, and F1 plants respectively

The smallness of the total number of plants observed and the chances of some of the members of the intermediate group exchanging with the purple coloured group on account of error of correct appreciation of colour may account for the deviations.

It may be noted that in both the crosses No. 1 and 6A the allelomorphs tally. The deviations of intermediates as to 1 : 1 : 2 ratio are slightly large but they can be explained on the bases of small numbers and possibility of error in appreciation of grades of colour, etc.

Summary.

1. Peat's and Harland's conclusions about the intermediate character of Spines and bloom are confirmed.
2. Three intensities of blooms are defined.
3. It is pointed out that simple bloom is dominant to no bloom and Treble bloom dominant to Double bloom.
4. Capsule colour in F_2 plants gives a ratio of 3 green and 1 coloured (pink or red) though F_1 is pink.
5. Stem colour in two crosses shows that in F_2 colour (all grades of red upto dark-purple-red) and no colour (all green) stand in the ratio of 3 : 1.

Literature Cited.

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3. RIDGEWAY R.—'Color Standards and Nomenclature' 1912. Washington.