PATTERNS OF ANTHOCYANIN INHERITANCE IN RICE

II. A Case of Spurious Linkage between Colour Genes of Stigma and Glumes

WHILE summarising linkage studies in rice, Ghose (1957) presented joint segregation for anthocyanin colour in stigma and glumes in a cross between two varieties, *Fukoku* × *Marichbeti*. Ghose considered that colour of each character was due to separate four genes giving a ratio of 162 coloured : 94 colourless plants in the F_2. Ghose thus thought that eight genes were involved in the production of anthocyanin pigment in these two parts. The joint segregation consisted of four classes and the smaller size of the recombinate classes apparently led him to believe that a linkage was involved. On the basis of independent segregation of eight genes the X^2 was very high. Ghose states that since no formulae were available for such ratios it was not possible to determine the cross-over value.

D'Cruz (1960) calculated "linkage" and states that the basic genes of each character are linked closely, giving a 2·02% cross-over value. On this basis he obtained very good approximation between the calculated and the observed frequencies of the four classes.

We had recently an occasion to critically examine the case and it appeared to us that there are two basic incongruities in the treatment of the data both by Ghose (1957) and D'Cruz (1960). The first is the assumption that eight genes are involved for production of anthocyanin colour for only two areas of the rice plant and the second is that two basic genes, similar in function, are closely linked. It is an extremely remote possibility, if not an impossibility, that so many genes for colour would be involved for only two characters. As regards D'Cruz's finding that two similar functioning basic genes, are very closely linked it should be stated that such a possibility would not occur as only one basic gene for anthocyanin production can be sufficient to produce colour in more than one part of the plant.

The results obtained by Ghose can be explained more logically on the basis of 4 colour genes and an inhibitor. The operation of the genes is indicated below :

TABLE I

Genes	Without inhibitor		With inhibitor, I-Sgp	
	Stigma	Glume	Stigma	Glume
C Sp ..	+	−	+	−
C Sgp_1 ..	+	+	−	−
C Sgp_2 ..	+	+	−	+

The basic chromogen gene, C, along with a specific complementary gene, Sp, for stigma, causes colour in the stigma region only. This gene is not affected by the inhibitor, I-Sgp. There are two more complementary genes, Sgp_1 and Sgp_2, which, in the absence of the inhibitor, produce colour with the basic gene C, in both stigma and glumes. However, the inhibitor suppresses colour in both the regions in the case of C Sgp_1 but only in the stigma region in the case of C Sgp_2.

On the basis of above interactions of the four colour genes and the inhibitor we get a 5 gene ratio of 504 : 117 : 108 : 295 of the four classes. The original data of Ghose and the calculated frequencies on various basis are presented in the statement below :

It will be seen from the statement that the agreement with observed frequencies is better and more logical on the basis of modified analysis as the deviations are smaller and the calculated recombinate classes are dissimilar unlike the classes obtained by D'Cruz on the basis of a linkage.

The ratio, for stigma is 621 coloured : 403 colourless plants. The deviation from the observed frequencies is of ± 9 plants with a X^2 of 0·6130 for one Degree of Freedom. For the glumes the ratio is 612 : 412 or 153 : 103 plants with coloured : colourless glumes. On this basis the deviation between the observed and expected population is of only ± 5 plants with a X^2 value of 0·1876. Without the inhibitor the ratios of coloured : colourless stigma would have been 189 : 67 and that of the glumes 45 coloured : 19 colourless. We may thus conclude that in the cross of *Fukoku* × *Marichbeti* the colour in the stigma is governed by four colour genes and in the glumes by three of the same four colour genes,

TABLE II

	Stigma and Glumes coloured	Stigma coloured, glumes colourless	Stigma colourless, glumes coloured	Stigma and glumes colourless	X^2	P
Obs. ..	281	64	55	154	..	..
(i) Cal. (162 : 94×162 : 94) Ind. (Ghose)	221·8	123·7	128·7	74·8	174·123	Very small
(ii) Cal. (2·02% C O.) (D'Cruz)	291·9	58·7	58·7	144·7	2·143	0·30–50
(iii) Cal. (504 : 117 : 108 : 295) (New)	272·7	63·3	58·4	159·6	0·6546	80-90

The inhibitor differentially modifies the interaction. There is no linkage.

A critical study of literature reveals that many anthocyanin genes have pleiotropic effects affecting from 2 to 11 characters. Shrivastava *et al.* (1968) report monogenic inheritance of colour in four parts, leaf-sheath, ligule, stigma and apiculus as a group in a variety JBS-294, which developed pigment in 11 parts. The results obtained by these authors, however, are better explained on the basis of 189 : 67 ratio, that is four colour genes. Recently Kadam (1970) has shown, in a reanalysis of Mitra and Ganguli's data (1932) in a wild rice of Assam that 4 colour genes cause development of anthocyanin pigment in 11 characters by teaming up in a variety of ways and an inhibitor affects two of the eleven characters.

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Poona-5, *February* 22, 1972. J. S. DESALE.

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