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Inheritance of Caryopsis/Ripened-Hull Colour in a Selection from Land Races of Rice *Oryza sativa* (Linn)

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Abstract: A cross was made between ERINMO 14 and OGIDE DWARF representing a cross between a cultivar with brown caryopsis and another with white caryopsis, respectively. The F_1 seeds were brown showing dominace of the brown character state. Results from the F_2 show that caryopsis colour is conditioned by a set of duplicate genes giving rise to 5 character states: Dark brown, brown, light-brown, dirty white and pure white. These character states can be explained on the basis of duplicate gene interaction with dosage effect. The ripened-hull colouration was found to be dependent on colour of the caryopsis such that spikelets with brown caryopses had brown ripened-hull while spikelets with white caryopses had straw ripened-hull. The implication of these findings for rice improvement are discussed.

Key words: Inheritence, rice, brown caryopsis, white caropsis, ripened-hull

INTRODUCTION

Pigmentation of various parts of the rice plant involves a complicated system of gene interaction, ranging from epistasis to peleiotropic effect (Chang, 1960). Anthocyanim pigmentation varies in intensity and distribution. It is present in all the vegetative parts and several floral parts but absent in the embryo or endosperm.

Plant pigments are often considered as minor agrobotanical characters by geneticists but they possess a lot of visual appeal in tracing gene through generations. For this reason, they are used as markers. It is generally accepted that anthocyanin colouration plays an important role, not only for the elucidation of gene regulation and character expression in plant metabolism, but also provides side effects for the tolerance to biotic and abiotic stresses (Maekawa, 1996).

Faluyi and Oloyede (1997) investigated the genetics of anthocyanin pigmentation in a purple cultivar of rice, TOS PURPLE. The purple leaf pigmentation is conditioned by two loci one of which carries an inhibitor gene I which inhibits purple pigmentation in the I-state. The gene for Purple Leaf (*Pl*) exerts pletotropic effect on all the organs except the inner leaf sheath whose colour it inhibits.

The pericarp, which give the hulled rice grain its characteristic colour is usually white but may be red, brown or rarely purple. Pigmentation does not extend deeper than the pericarp; the endosperm is always white. Nagao and Takahashi (1947) claimed that complementary genes, which they designate *Rc* and *Rd*, were concerned in the expression of red colour in the pericarp.

This study reports the genetics of inheritance of caryopsis/ripened-hull colour in a selection from land races of rice *Oryza satwa* Linn.

MATERIALS AND METHODS

A cross was made between an accession with brown caryopsis (ERINMO 14) and another with white caryopsis (OGIDE DWARF). The plants were raised in cups and later transplanted to the field. The spikelets of the F_1 plant was dehulled and the caryopses were scored for colour. The F_2 seeds were planted to raise F_2 plants.

Improperly-dried seeds and establishment of standard for all the grades and hues of the colour classes were two major problems that made analysis difficult. The panicles which were harvested when dried on the field and were dried further in the drier before peeling was done to remove impurity in drying.

Spikelets from individual F_2 panicles were dehulled and scored for colour segregation to determine F_3 caryopsis colour ratios and subsequently validate the pattern of inheritance exerted by the ratio. The F_3 population was classified into pure colour + segregants for colourations and pure white caryopsis.

The ratios were subjected to Chi-Square analysis to determine the mode of inheritance. Ripened-hull colouration was scored on the F_1 and F_2 plants and the results were analysed as done for caryopsis colour.

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Table 1: Classification for caryopsis colour in the F_2 population of the ERINMO 14 X OGIDE DWARF F_2

	No of caryopsis			Total
Cross	Brown	White	Total	χ^2 15:1
ERINMO 14 X OGIDE DWARF F_2	946	54	1000	1.233 0.1≥p≥0.5

Table 2: Classification of the F families of the ERINMO 14 X OGIDE DWARF for caryopsis colour segregation states

	No of caryopsis			
Cross	All coloured + Segregant	All pure White	χ^2 15:1	Total
ERINMO 14 X OGIDE DWARF F	294	26	320	1.920 0.1≥p≥0.5

Fig. 1: Caryopsis colour in the ERINMO 14 X OGIDE DWARF F_2 and F, A. Brown Caryopsis, B. Pure dark-brown caryopsis, C. Light-brown caryopsis, D. Pure white caryopsis, E. Dirty-white caryopsis

RESULTS

The ERINMO 14×OGIDE DWARF hybrid represents a cross between a cultivar with brown caryopsis and white caryopsis. The hybrid seed was brown while the F_2 seeds segregated 946 brown: 54 white fitting a 15 coloured to 1 white ratio as shown in Table 1.

Table 2 shows the classification of F_3 families for pure colouration and segregation for caryopsis colour states on one hand and the pure white caryopsis phenotypic class on the other hand. The data show that 294 F_2 plants had their F_3 caryopsEs either pure dark, brown light-brown or segregating for all shades of brown, including dirty-white and pure white while 26 F_2 plants had pure white caryopsis (Fig. 1). This data fits a 15 all colour + segregating: 1 pure white ratio, the classical expectation on the basis of duplicate gene interaction.

Table 3 presents the assignments of genotypes for the various phenotypic states observed. The duplicate gene model already implicated is modified by the dosage effect of the major gene. Gene *Rc* is the gene assigned for brown caryopsis colour (RGN 7: 32). This gene is in linkage group 7. Dark brown, brown, dirty-white and pure white caryopsis colour will be conditioned by 4, 3, 2, 1 and 0 does of gene *Rc*.

Table 3: Assignment of genotypes based on the duplicate gene hypothesis for caryopsis colour

Phenotype	Genotype	Frequency	Cumulative Frequency
Dark brown	$Rc_1Rc_1Rc_2Rc_2$	1	1
Brown	$Rc_1rc_1Rc_2Rc_2$	2	4
	$Rc_1Rc_1Rc_2rc_2$	2	
Light brown	$Rc_1rc_1Rc_2rc_2$	4	
	$Rc_1Rc_1rc_2rc_2$	1	6
	$rc_1rc_1Rc_2Rc_2$	1	
Dirty white	$Rc_1rc_1rc_2rc_2$	2	4
	$rc_1rc_1Rc_2rc_2$	2	
White	$rc_1rc_1rc_2rc_2$	1	1

Three major observations were made with respect to the ripened-hull colour. The first is that panicles with all-brown caryopses in the F_3 had brown ripened-hull while the second is that panicle that had all-white caryopses had straw ripened-hull. The third observation is that in panicles whose caryopses segregated for colour, straw hull bore white caryopses while brown hull bore brown caryopses. Similarly, empty hulls in all-brown caryopses F_2 panicles were straw.

The third observation poses a problem because it has already been observed that the grain characters are one generation ahead of that of the vegetative part of the plant which includes the hull.

DISCUSSION

The genetic model that explains the inheritance of caryopsis colour in ERINMO 14 is the duplicate gene with dosage effect. Caryopsis colour is determined at two loci by a set of duplicate genes giving rise to 5 character states: Dark-brown, brown, light-brown, dirty white and white, corresponding to 4, 3, 2, 1 and 0 dominant genes.

Takahashi (1957) invoked the action of complementary genes designated *Rc* and *Rd* in the expression of red colour in the rice pericarp; the genotypes rcRd and rcrd express white caryopsis. Hector (1922) and Jones (1933) reported instances where red pericarp exhibits simple dominance. Seetharaman (1964) reported that the inheritance scheme in japonica rice does not fit the scheme in indica rice. The model reported in this study is different from the ones in the literature cited. The point must be made however that the model of Takahashi (1957) involves non-allelic interaction as the one being proposed in this study.

The ripened-hull colour states recognised in the Descriptor are straw, brown, gold, purple, black, tawny. The two ripened-hull colour states in this study are brown (ERINMO 14) and straw (OGIDE DWARF).

Nwokeocha (1998) and Aladejana (2000) investigated the genetics of inheritance of straw and black hull colouration in *Oryza barthii*. The 2 workers reported 9black: 7straw implicating complementary gene action.

The results obtained in this work suggest that the brown ripened-hull colour in ERIMO 14 was imparted by the brown caryopsis colour gene and not by an independent gene. The observation of brown and straw ripened hull seen on the F_1 panicle with straw corresponding to white caryopsis corroborate the fore-going interpretation. The same event was observed in the F_2 panicle that were segregating for caryopsis colour. In addition, empty spikelets in all-brown-caryopses panicles in the F_2 were straw proving that the pigment in the brown hulls was leached out of their caryopses. The point has been made earlier on that the hull is one generation behind its caryopsis.

The significance of this study is that the exploration of genetic resources does not have to be limited by the grain colour of a variety. The incidence of brown caryopses is very rich in our land races to the extent that almost every selection can be made in the two caryopses versions.

Genetic stocks of valuable agronomic traits in known caryopses can be exploited in rice improvement with the understanding that larger populations will be required for selection in breeding varieties with white caryopsis.

The analysis of the inheritance of ripened-hull colour in the cultivar studied underscores the need for indepth reconciliation of data with all related basic principles in genetic analysis. The genetical analysis of segregation data for ripened-hull would have assigned a gene for the brown ripened-hull colour. Pleiotropy is ruled out because the empty hull in the all-brown-caryopses panicles would have been brown. The brown ripened-hull colour in ERINMO 14 is an environmental effect produced by leaching pigment from the brown caryopsis.

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