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Original Research Article

Genetic Inheritance of Anthocyanin Pigment in the Derivatives of Nutritive Landrace 'Kavuni' (*Oryza sativa* L.)

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A B S T R A C T

Anthocyanin pigment confers to different metabolic events in plants which are indeed helpful to the mankind. The experiment includes two sets of crosses ASD 16 x Kavuni and Swarna Sub1 x Kavuni representing the cross between white rice (ASD 16, Swarna Sub1) and dark purpled coloured rice (Kavuni). The F_1 seeds were purple showing the dominance of the purple colour trait. Results from the F_2 generation show that caryopsis or pericarp is conditioned by a set of duplicate genes giving the shades of hue in the purple colour: Dark purple, purple, light purplish brown, dirty white and white. These character states can be explained on the basis of duplicate dominant epistasis (15:1) with dosage effect. The ripened hull colouration was found to be dependent on the colour of the pericarp such that spikelets with darker colour had dark ripened hull, while the white grains had straw coloured hull. The present study was undertaken to investigate the inheritance pattern of pericarp colour and ripened hull colour and the implication of these findings for rice improvement are discussed.

Keywords

Anthocyanin, Kavuni, inheritance, Pericarp, Hull, Gene action

Introduction

Most of the rice consumed is the white coloured, although many rice cultivars have a variety of seed pericarp colours owing to black (dark purple), brown, red and green pigments deposition (Furukawa *et al.*, 2006) due to the accumulation of anthocyanins in the pericarp. Anthocyanins are members of a class of nearly universal, water soluble, terrestrial plant pigments that can be classified chemically as both flavonoids and Phenols (Shirley *et al.*, 1998). Many functions are attributed to the anthocyanins are protection from UV light, defence against pathogen and insect attack, singnaling molecules in the nodulation process, response to wounds and resistance to a variety of biotic and abiotic stresses. Anthocyanins act as antioxidants that can clean up cholesterol in the blood, prevents anemia, potentially increasing the body's resistance to disease, improve liver cell damage (hepatitis and chirrosis), prevent impaired kidney function, prevent cancer/tumor, slow the aging (antiaging) (Harmanto, 2008), as well as to prevent narrowing of the arteries (atherosclerosis). Research on inheritance of pigment pericarp of black rice was conducted by Hsieh and Chang (1964); Mingwei *et al*. (1995); Sahu *et al*. (2011) and Rahman *et al*. (2013). The pattern of inheritance of pigment rice has shown different gene models of complementary gene model and duplicate dominant epistasis. This study reports the genetics of inheritance of pericarp and ripened hull colour in a selection from nutritive landrace of India Kavuni.

Materials and Methods

Two sets of crosses were performed using ASD 16 (ADT 31/ CO 39), Swarna Sub1 (Swarna / FR13A) having green stem, colourless stigma and white grain or caryopsis as female parents with medicinal landrace Kavuni with purple stem, purple stigma and purple grain (pericarp). The spikelets of the F_1 plant were dehulled and the caryopses were scored for colour. The F_2 seeds were planted to raise F_2 plants. The shades of the purple colour were identified by the colour leaflets developed by The Royal Society of Horticulture (Figure 1). The pericarps were scored for colour segregantion to determine caryopsis colour ratio and subsequently validate the inheritance pattern by the ratio. The data was analyzed for colour pigmentation to determine the fitness with diverse segregation ratios to determine mode of inheritance by $\chi 2$ (Chi-square) test as suggested by Fisher (1936).

Results and Discussion

Genetics of qualitative pigmentation characters

Among the parents used in hybridization programme, the female parents ASD 16 and Swarna sub1 had white coloured pericarp and straw coloured hull while the male parent Kavuni had purple coloured pericarp and purple coloured hull (Figure 2). The F_1 genotypes of both the cross ASD 16 x Kavuni and Swarna sub1 x Kavuni produced purple pericarp with purple hull colour. In F_2 population of each cross, the individual plants were evaluated for phenotypic expression of pericarp colour and hull colour. In the cross, ASD 16 x Kavuni, out of 580 plants evaluated 542 plants had purple pericarp colour and 38 showed white pericarp colour (Figure 3). In cross the Swarna Sub1 x Kavuni, 446 plants exhibited purple colour and 32 resulted in white colour among 478 individuals of F_2 segregants (Table 1). In case of 478 F_2 genotypes of Swarna Sub1 x Kavuni, 31 plants had straw coloured hull and 447 genotypes were observed with purple hull colour. Among 580 individuals of F_2 plants (ASD 16 x Kavuni), 551 exhibited purple hull while 29 were with straw coloured hull. Chi-square ($\chi 2$) test was performed to test the goodness of fit of the both F_2 populations for the phenotypic data by comparing an observed frequency distribution with an expected one. The observed frequencies when tested for goodness of fit with chi-square ($\chi 2$) test for duplicate dominant epistasis gene model showed goodness of fit to the expected phenotypic segregation ratio of (15:1).

The duplicate gene model with dosage effect explains the inheritance of the pericarp colour in Kavuni. Pericarp or caryopsis colour is determined at two loci by a set of duplicate genes giving rise to 5 Character states: Dark purple, purple, light purplish brown, dirty white and white, corresponding to 4, 3, 2, 1 and 0 dominant genes.

Based on the results the purple ripened hull colour in Kavuni is imparted by the purple caryopsis colour gene. The purple and straw coloured hull corresponds to purple and white colour pericarps respectively. The events of pigmentation is observed in F_1 and F_2 generation and empty spikelets in all purple pericarp panicles in the F_2 were straw coloured giving an indication that the pigment in the purple hulls has been leached out of their caryopses and pertaining to other environmental factors. These findings are in the same way and similar to the findings of Ayoola and Faluyi 2007,where brown pigmentation of ERIMO 14 inherited in duplicate dominant gene model (15:1) with dosage effect (Table 1).

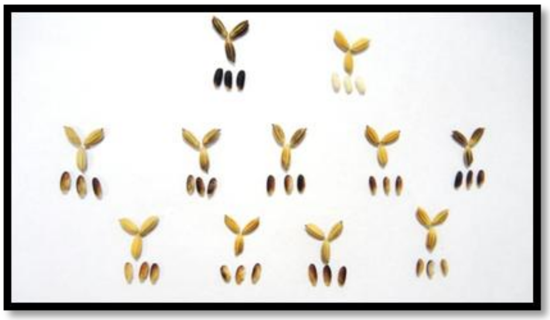
Table.1 Genetics of qualitative pigmentation characters

S. No.	Plant characters / crosses	P1 × P2	F_1 Phenotypes	F_2 observations		χ2 ratio	χ2Value
1	**Pericarp colour**						
	ASD 16 x Kavuni	White x Purple	Purple	Purple	542	15:1	0.007^{NS}
				white	38		0.105^{NS}
				Total	580		
	Swarna Sub1 x Kavuni	White x Purple	Purple	Purple	446	15:1	0.242^{NS}
				white	32		0.689^{NS}
				Total	478		
2	**Hull Colour**						
	ASD 16 x Kavuni	Straw hull x Purple	Purple	Purple	551	15:1	0.716^{NS}
				Straw hull	29		1.590^{NS}
				Total	580		
	Swarna Sub1 x Kavuni	Straw hull x Purple	Purple	Purple	447	15:1	0.002^{NS}
				Straw hull	31		0.041^{NS}
				Total	478		

Figure.1 Gradation of Seed colour using seed colour chart

Figure.2 Pericarp and hull colour variants of Swarna Sub1, Kavuni and ASD 16

Figure.3 Colour segregants for hull and pericarp colour of F_2 derivaties of ASD 16 / Kavuni



The occurrence as well as distribution of anthocyanin pigmentation in different parts of the rice plant are highly variable and are striking features of the crop. It is observed that anthocyanin colouration plays an important role not only for the elucidation of gene regulation and also acts as morphological indicator for the tolerance to biotic and abiotic stresses (Hemaprabha *et al.*, 2007).

Sastry (1978) and Sahu *et al.* (2010) reported simple gene action for the red pericarp. Pavithran *et al.* (1995) reported that the F_2 population segregated into the ratio of 45:19 (red to white pericarp), suggesting that expression of red pericarp colour was imparted by three genes involving two major genes either of them complementing with another dominant gene, to be responsible for the trait. Nadaf *et al.* (1995) and Kristamtini *et al.* (2019) reported inheritance of complementary gene action for this trait in the derivatives of native black rice of Indonesia.

The significance of the study states that the genetics of the pigmentation in the rice varies from simple to complex phenomenon based on the results and available reports on the genetics of anthocyanin pigmentation. The analysis of inheritance of pigmentation underscores the need of indepth reconciliation of the data and genetic stocks of nutritional and valuable agronomic traits with pigmented caryopses can be exploited for stress tolerance, biofortification and crop improvement studies in rice.

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