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Siddharth R Kadam
Agricultural Research Station,
Palghar, Valan Naka, Dr.
Balasaheb Sawant Konkan
Krishi Vidyapeeth,
Maharashtra, India

Sanjay G Bhawe
Agricultural Research Station,
Palghar, Valan Naka, Dr.
Balasaheb Sawant Konkan
Krishi Vidyapeeth,
Maharashtra, India

Deepak K Borse
Agricultural Research Station,
Palghar, Valan Naka, Dr.
Balasaheb Sawant Konkan
Krishi Vidyapeeth,
Maharashtra, India

Santosh V Sawardekar
Agricultural Research Station,
Palghar, Valan Naka, Dr.
Balasaheb Sawant Konkan
Krishi Vidyapeeth,
Maharashtra, India

Corresponding Author:
Siddharth R Kadam
Agricultural Research Station,
Palghar, Valan Naka, Dr.
Balasaheb Sawant Konkan
Krishi Vidyapeeth,
Maharashtra, India

Inheritance of pericarp and hull colour pigments on crossing between white rice and red rice (*Oryza sativa* L.)

Siddharth R Kadam, Sanjay G Bhawe, Deepak K Borse and Santosh V Sawardekar

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Abstract

The occurrence as well as distribution of anthocyanin pigmentation in different part of the rice plant are more variable and a striking feature of the crop. This feature has been the subject of interest for several earlier studies. This experiment included 24 crosses between six white pericarp rice and four red pericarp rice following line x tester method of crossing. All F₁ seeds from white rice x red rice crosses produced red pericarp colour grain, confirmed that red pericarp colour was a dominant trait. Proportion of plants with red and white pericarp in F₂ population closely fitted in the ratio of 3:1 (red:white). In case of genetics of hull colour trait in the present study, the crosses between straw hull x brown hull, golden hull x brown hull, straw hull x black hull and golden hull x black hull colour, it was observed that brown hull was dominant over straw hull and golden hull, golden hull was dominant over straw hull and black hull was dominant over golden hull colour, indicating dominant nature of these hull colours in F₁ generation. The F₂ population of these crosses segregated into ratio of 13:3. This result revealed that anthocyanin pigmentation on hull colour was due to two independent genes, one dominant and other one recessive. The present study was undertaken to investigate the inheritance pattern of pericarp colour and ripen hull colour. The implications of these findings for rice improvement are discussed.

Keywords: Inheritance, pericarp colour, hull colour, Rice

Introduction

Rice (*Oryza sativa* L.) is one of the major staple food crop being grown worldwide. It provides 20 per cent of the calories and 15 per cent of protein consumed by world's population. Besides being the chief source of carbohydrate and protein, it also provides minerals and fibre. This crop is the backbone of livelihood for millions of rural households and plays vital role in the country's food security, so the term "rice is life" is most appropriate in Indian context.

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. Red rice constitute a small but special group of rice which are considered the best in quality in view of nutritive purpose. In India, rice is often considered the main culprit in aggravating the diabetic condition. For all those people, relief is now available in the form of brown rice and red rice.

Red rice is a special variety of rice that gets its red colour due to anthocyanins. This rice is generally unhulled or partially hulled rice which has a red pericarp colour. As it contains anthocyanins, it helps in reducing inflammation, allergy, preventing risks of cancer and helping in weight management. Manganese in red rice helps in strengthening metabolism, Magnesium helps in migraine, lowers blood pressure as well as reduces the risk of heart attacks. Selenium in red rice protects the body against infections.

Materials and Methods

The present investigation was carried out at Educational and Experimental Farm, Department of Agriculture Botany, College of Agriculture Dapoli, Tal- Dapoli, Dist- Ratnagiri during Kharif -2019 and Rabi 2019-20 and at experimental farm, Agriculture Research Station,

Palghar, Dist. Palghar during *Kharif*-2020.

The experimental material for present investigation consisted of 36 entries including 6 females, 4 males, their 24 crosses and two checks. All the females were semi-dwarf, high yielding, white pericarp, fine grain type rice varieties which are used as lines, while all males were red pericarp land races used as testers in this experiment. The crosses were developed by line x Tester fashion given by Kempthorne in 1957^[4].

Evaluation of pericarp pigment of the rice is done on each

individual rice plants. Rice pericarp pigment of each population morphology observed with partial peeling grains. The spikelets of the F₁ plant were dehulled and the caryopses were scored for colour. The F₁ seeds were planted to raise F₂ progeny. The pericarps were scored for colour segregation to determine caryopsis colour ratio and subsequently validate the inheritance pattern by the ratio. Rice pigment observation based scoring colors as shown in Table 1. Kristamtini *et al.* (2019)^[5].

Table 1: Score of pigment of rice

Trait	Score	Characteristic properties
Black	1	The percentage of black pigment in a single grain of rice $\geq 50\%$; referred to as Black = B
Medium black	2	The percentage of black pigment in a single grain of rice $< 50\%$; referred to as Medium Black = MB
Red	3	The percentage of red pigment in a single grain of rice 100%, referred to as Red = R
White	4	The percentage of white pigment in a single grain of rice 100%, referred to as White = W

Present study was conducted to investigate genetic basis of anthocyanin pigmentation of two qualitative characters *viz.*, hull colour and pericarp colour. The Chi-square (χ^2) test was applied to test the goodness of fit for the expected Mendelian ratio. It is given by the formula,

$$\chi^2 = \sum_{i=1}^n \frac{(O_i - E_i)^2}{E_i} \text{ With } (n-1) \text{ d.f.}$$

Where,

O - Observed frequencies.

E - Expected frequencies.

N - Number of classes.

d. f. - Degree of freedom.

Σ - Summation of all classes.

The χ^2 test is a valuable tool that aids investigator in determining the goodness of fit of genetic ratios Fisher, (1936)^[1]. The expected values corresponding to the observed values for each characters were calculated based on the presumed ratio. The deviations were put to χ^2 test. If the deviation of expected frequencies from the observed ones were small χ^2 would approach to zero and it would be less than 3.841 at 5 per cent level of significance and one degree of freedom. So the deviations were taken as non-significant and the ratio presumed was taken as fit. But if the deviations were large the χ^2 would be more than 3.841 at 5 per cent level of significance and one degree of freedom and the goodness of fit would be poor.

Results and Discussion

Pericarp colour

The F₁ plants of all the crosses were found to have red pericarp colour. This indicated that red pericarp colour was dominant over white pericarp colour. These F₁ progenies were observed in F₂ generation for pericarp colour. The proportion of plants with red and white pericarp in F₂ population closely fitted in the ratio of 3:1 (red to white Pericarp) for all 24 crosses, this indicated that red colour of pericarp in all testers Bela, Munga, Valai and Kudai was governed by single dominant gene.

Qualitative traits differ markedly in their expression among the individuals of a species. Such characters are under the control of major genes. The occurrence as well as distribution of anthocyanin pigmentation in different part of

the rice plant are more variable and are a striking feature of the crop. This feature has been the subject of interest for several earlier studies. Such morphological variants with distinct phenotypic expression and simple inheritance pattern can be used to establish linkages and for indirect selection if found associated with useful traits (Reddy *et al.*, 1995)^[6].

Gealy *et al.* (2006)^[2] observed that F₁ plants from white rice x red rice combinations produced red seeds, confirming that red seed colour is a dominant trait. F₂ populations derived from LA₃ or TX₄ red rice segregated in ratios of approximately 3:1 (red:white) seed colouration, consistent with single dominant gene control of this trait. In the present investigation, the mode of inheritance of red pericarp was studied in 24 crosses. Red pericarp commonly known as red rice. All F₁ plants from white rice x red rice crosses produced red pericarp colour, confirmed that red pericarp colour was a dominant trait. Proportion of plants with red and white pericarp in F₂ population closely fitted in the ratio of 3:1 (red:white) seed colouration (Table 2). It showed that the red pericarp colour is dominant over white pericarp colour. It indicated that red colour of pericarp in the varieties Bela, Munga, Valai and Kudai was governed by a single dominant gene. This is in consonance with the findings of Hemprabha *et al.* (2007)^[3], Sahu *et al.* (2010)^[7] and Waghmode *et al.* (2017)^[8].

Hull colour

Genetics of hull colour was studied in 24 crosses. The F₁ plants of 10 crosses between straw hull colour (female) and brown hull colour (male) parents *viz.*, Karjat 4 x Bela, Palghar 1 x Bela, Rtanagiri 5 x Bela, Ratnagiri 6 x Bela, Trombay Karjat Kolam x Bela, Karjat 4 x Munga, Palghar 1 x Munga, Rtanagiri 5 x Munga, Ratnagiri 6 x Munga and Trombay Karjat Kolam x Munga were observed all brown hull colour, indicating dominant nature of trait. The proportion of plants with brown and straw hull colour in F₂ population closely fitted in the ratio of 13:3. The χ^2 analysis on the segregation data showed goodness of fit to 13:3 genetic ratio for the hull colour indicating the digenic inheritance with inhibitory gene interaction.

In five crosses which females (Karjat 4, Palghar 1, Ratnagiri 5, Ratanagiri 6 and Trombay Karjat Kolam) having straw hull colour and blackish brown hull colour male (Kudai) showed all blackish brown hull coloured F₁ plants. This indicated that blackish brown hull colour was dominant over

straw hull colour. These F_1 progenies were observed in F_2 generation for hull colour. The proportion of plants with blackish brown hull colour in F_2 population closely fitted in the ratio of 9:7 indicating the action of two major genes either of them complementing with other dominant gene responsible for expression of hull colour.

The cross between golden hull colour female (Karjat 9) and brown hull colour males (Bela and Munga) recorded brown hull colour and cross Karjat 9 x Valai having golden hull colour (female) and straw hull colour (male) parents was observed golden hull colour, while cross Karjat 9 x Kudai having golden hull colour (female) and black hull colour (male) parents was observed black hull colour indicating dominant nature of trait. The proportion of plants with golden to brown and golden to straw and golden to black hull colour in F_2 population closely fitted in the ratio of 13:3 genetic ratio for the hull colour indicating the digenic inheritance with inhibitory gene interaction.

The observations on hull colour (straw or purple/straw or red) and pericarp colour (white or red) recorded at appropriate stage of crop. The observations on the parents and F_1 's were recorded on row basis, while F_2 population on individual plant basis. The data were analysed independently for each trait to determine the fitness with diverse segregation ratios to determine mode of inheritance by χ^2 (Chi-square) test as suggested by Fisher (1936) [1].

Sahu *et al.* (2010) [7] reported that, the proportion of purple hull and straw hull plants in the F_2 population of the cross Mahamaya x Mainagali closely fitted to the ratio of 13

purple: 3 straw hull. This result revealed that anthocyanin pigmentation on lemma palea in the variety Mainagali was due to two independent genes, one dominant and other one recessive ($Pr-1$, $pr-2$). In case of genetics of hull colour trait in the present study, the crosses between straw hull x brown hull, golden hull x brown hull, straw hull x black hull and golden hull x black hull colour, it was observed that brown hull was dominant over straw hull and golden hull, golden hull was dominant over straw hull and black hull was dominant over golden hull colour, indicating dominant nature of these hull colours in F_1 generation. The F_2 population of these crosses segregated into ratio of 13:3. This result revealed that anthocyanin pigmentation on hull colour was due to two independent genes, one dominant and other one recessive. The result was in agreement with Hemprabha *et al.* (2007) [3] and Waghmode *et al.* (2017) [8]. Whereas, Sahu *et al.* (2010) [7] also reported these dominant and recessive gene as $Pr-1$, $pr-2$.

The remaining five crosses between black hull colour x straw hull colour found to have all black hull colour F_1 progeny. It indicated the dominant effect of black hull colour over straw hull colour. The F_2 population of all five crosses segregated into ratio of 9:7 black hull to straw hull, indicating two independent recessive genes responsible for expression of hull colour in the varieties. The results were in accordance with Hemprabha *et al.* (2007) [3], Sahu *et al.* (2010) [7] and Waghmode *et al.* (2017) [8], Sahu *et al.* (2010) [7] also reported these recessive genes as $hr1$ and $hr2$.

Table 2: Segregation pattern of the progenies of the crosses between white pericarp and red pericarp colour in F_2 population

Cross no.	Name of cross	P_1 / P_2	F_1 Phenotypes	No. of red/ white pericarp colour plants in F_2 population		χ^2 ratio	χ^2 value	P value
				Red	White			
Cross 1	Karjat 4 x Bela	White/Red	Red	1487	491	3:1	0.69	0.50-0.30
Cross 2	Karjat 4 x Munga	White/Red	Red	1402	438	3:1	1.40	0.30-0.20
Cross 3	Karjat 4 x Valai	White/Red	Red	1559	556	3:1	1.87	0.20-0.10
Cross 4	Karjat 4 x Kudai	White/Red	Red	1604	514	3:1	0.60	0.50-0.30
Cross 5	Karjat 9 x Bela	White/Red	Red	1538	522	3:1	1.02	0.30-0.20
Cross 6	Karjat 9 x Munga	White/Red	Red	1474	521	3:1	1.32	0.30-0.20
Cross 7	Karjat 9 x Valai	White/Red	Red	1394	492	3:1	1.19	0.30-0.20
Cross 8	Karjat 9 x Kudai	White/Red	Red	1495	542	3:1	2.81	0.10-0.05
Cross 9	Palghar 1 x Bela	White/Red	Red	1609	543	3:1	0.72	0.50-0.30
Cross 10	Palghar 1 x Munga	White/Red	Red	1418	445	3:1	1.23	0.30-0.20
Cross 11	Palghar 1 x Valai	White/Red	Red	1506	539	3:1	2.01	0.20-0.10
Cross 12	Palghar 1 x Kudai	White/Red	Red	1470	512	3:1	0.73	0.50-0.30
Cross 13	Ratnagiri 5 x Bela	White/Red	Red	1638	540	3:1	0.91	0.50-0.30
Cross 14	Ratnagiri 5 x Munga	White/Red	Red	1633	515	3:1	1.20	0.30-0.20
Cross 15	Ratnagiri 5 x Valai	White/Red	Red	1370	487	3:1	1.49	0.30-0.20
Cross 16	Ratnagiri 5 x Kudai	White/Red	Red	1579	480	3:1	3.13	0.10-0.05
Cross 17	Ratnagiri 6 x Bela	White/Red	Red	1367	461	3:1	0.78	0.50-0.30
Cross 18	Ratnagiri 6 x Munga	White/Red	Red	1534	544	3:1	1.54	0.30-0.20
Cross 19	Ratnagiri 6 x Valai	White/Red	Red	1620	566	3:1	0.93	0.50-0.30
Cross 20	Ratnagiri 6 x Kudai	White/Red	Red	1475	463	3:1	1.27	0.30-0.20
Cross 21	TKK x Bela	White/Red	Red	1531	515	3:1	2.56	0.20-0.10
Cross 22	TKK x Munga	White/Red	Red	1588	562	3:1	1.49	0.30-0.20
Cross 23	TKK x Valai	White/Red	Red	1424	454	3:1	0.68	0.50-0.30
Cross 24	TKK x Kudai	White/Red	Red	1601	505	3:1	1.17	0.30-0.20

Table value at 1 d.f. and 0.05% level of significance = 3.84

Table 3: Segregation pattern of the progenies of the crosses between different hull colour in F₂ generation.

Cross No.	Name of cross	P ₁ / P ₂	F ₁ Phenotypes	Number of plants observed in F ₂		χ^2 ratio	χ^2 value	P value
				Brown	Straw			
Cross 1	Karjat 4 x Bela	Straw/Brown	Brown	1590	388	13:3	0.973	0.50-0.30
Cross 9	Palghar 1 x Bela	Straw/Brown	Brown	1722	430	13:3	2.142	0.20-0.10
Cross 13	Ratnagiri 5 x Bela	Straw/Brown	Brown	1742	436	13:3	2.300	0.20-0.10
Cross 17	Ratnagiri 6 x Bela	Straw/Brown	Brown	1460	368	13:3	2.289	0.20-0.10
Cross 21	Trombay Karjat Kolam x Bela	Straw/Brown	Brown	1639	407	13:3	1.753	0.20-0.10
Cross 2	Karjat 4 x Munga	Straw/Brown	Brown	1478	362	13:3	1.031	0.50-0.30
Cross 10	Palghar 1 x Munga	Straw/Brown	Brown	1531	332	13:3	1.056	0.50-0.30
Cross 14	Ratnagiri 5 x Munga	Straw/Brown	Brown	1762	386	13:3	0.857	0.50-0.30
Cross 18	Ratnagiri 6 x Munga	Straw/Brown	Brown	1662	416	13:3	2.197	0.20-0.10
Cross 22	Trombay Karjat Kolam x Munga	Straw/Brown	Brown	1722	428	13:3	1.889	0.20-0.10
				Black	Straw			
Cross 4	Karjat 4 x Kudai	Straw/Black	Blackish brown	1179	881	9:7	0.809	0.50-0.30
Cross 12	Palghar 1 x Kudai	Straw/Black	Blackish brown	1199	979	9:7	1.273	0.30-0.20
Cross 20	Ratnagiri 6 x Kudai	Straw/Black	Blackish brown	1122	937	9:7	2.584	0.20-0.10
Cross 16	Ratnagiri 5 x Kudai	Straw/Black	Blackish brown	1116	822	9:7	1.404	0.30-0.20
Cross 24	Trombay Karjat Kolam x Kudai	Straw/Black	Blackish brown	1212	894	9:7	1.446	0.30-0.20
				Brown	Golden			
Cross 5	Karjat 9 x Bela	Golden/Brown	Brown	1654	406	13:3	1.243	0.30-0.20
Cross 6	Karjat 9 x Munga	Golden/Brown	Brown	1594	401	13:3	2.388	0.20-0.10
				Golden	Straw			
Cross 7	Karjat 9 x Valai	Golden/Straw	Golden	1560	326	13:3	2.656	0.20-0.10
				Black	Golden			
Cross 8	Karjat 9 x Kudai	Golden/Black	Blackish brown	1629	408	13:3	2.189	0.20-0.10

Table value at 1 d.f. and 0.05% level of significance = 3.84

Conclusion

The study on rice pericarp and hull color genetics demonstrated that red pericarp color is controlled by a single dominant gene, with F₂ segregation fitting the 3:1 ratio. Similarly, hull color exhibited more complex inheritance patterns. Brown hull color was dominant over straw and golden hull colors, and black hull color was dominant over straw, with F₂ segregation fitting 13:3 and 9:7 ratios, respectively. These findings confirm that both pericarp and hull colors in rice are influenced by major genes with simple and digenic inheritance patterns. The study aligns with previous research and provides insight into genetic control of rice pigmentation traits.

References

1. Fisher RA. On the interpretation of χ^2 from contingency tables and the calculation of P. J Royal Stat Soc. 1936;85(1):87-94.
2. Gealy DR, Yan W, Rutger JN. Red rice (*Oryza sativa* L.) plant types affect growth, coloration, and flowering characteristics of first- and second-generation crosses with rice. Weed Technol. 2006;20:839-852.
3. Hemprabha E, Thiruvengadam V, Maheswaran M, Shanmugasundaram P. Inheritance of anthocyanin pigmentation in rice (*Oryza sativa* L.). Plant Arch. 2007;7(2):549-552.
4. Kempthorne O. An introduction to genetic studies. New York: John Wiley & Sons Inc.; c1957.
5. Kristamtini, Taryono, Panjisakti B, Murti RH. Inheritance of pericarp pigment on crossing between black rice and white rice (*Oryza sativa* L.). Songklanakarin J Sci Technol. 2019;41(2):383-388.
6. Reddy VS, Dash S, Reddy AR. Anthocyanin pathway in rice (*Oryza sativa* L.): identification of a mutant showing dominant inhibition of anthocyanins in leaf and accumulation of proanthocyanidins in pericarp. Theor Appl Genet. 1995;91:301-312.

7. Sahu GR, Sarawgi AK, Sharma B, Parikh M. Inheritance of anthocyanin pigmentation in rice. J Rice Res. 2010;3(1):20-27.
8. Waghmode BD, Kadam SR, Sonone NG, Navhale VC. Analysis of paddy cultivars for iron and zinc content in their brown rice. In: Proceedings of the 1st National Convention, Emerging Trends in Agricultural and Allied Science; c2017. p. 49-50.