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Genetic Analysis of Important Qualitative Traits in Rice (Oryza Sativa L.)

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Abstract:- The morphological marker like auricle and ligule colour is important traits useful for varietal profiling and other genetic studies. This research was aimed at analysis of genetic of the auricle and ligule colour in the F1 and segregating generations (F_2 and F_3) of 06 crosses,IC-548384 × Chandrahasini, IC-390376 × Chandrahasini, IC-390376 × Samleshwari, IC-134022 × Durgeshwari, IC-388728 × Chandrahasini, IC-389860 × Samleshwari.Results revealed that the inheritance of auricle colour shown duplicate epistasis 15(Green): 1Purple ratio), controlled by two major genes. Whereas, inheritance of ligule colour was recorded to have digenic complementary interaction (9:7 ratio) across the studied family.

Keywords:- *Morphological marker, Major gene, Inheritance, Segregants, complementary.*

I. INTRODUCTION

Rice, maize, wheat, and soybean are the four major crop with a increasing yield rate of 0.9-1.3% per year which is not in short supply to encounter the food challenge for the estimated nine billion population of World in 2050 (Ray et al. 2013). Among all the crops, Rice (*Oryza sativa* L.) (2n=24) plays a major role that has been referred as “Global Grain” because of its use as prime staple food in about 100 countries of the world (Syed and Khaliq, 2008). Oligo-genic traits which exerts discrete variances within family are found highly heritable, remains constant in course of inheritance are imperative for varietal profiling. These are important and reliable indices for the identification of the various species, varieties, genotypes, ecotypes and all sorts of intermediates between the species as well as natural and putative hybrids and segregants. Study of broad variability and pigmentations in different plant part is very important for the varietal documentation and marker traits which are used in breeding program(Maurya et al. 2001). Most of the wild rice and related species are sources of different biotic and abiotic stress genes. These genes can be transferred to cultivated rice (*Oryza sativa* L.) to improve the biotic and abiotic stress through hybridization (Ali et al. 2015). Besides, these can be a better tool in the understanding of the population dynamics of the indigenous species. Kim et al., 2016, identified six wild subpopulations and out of which three subpopulations were genetically and geographically related to O. sativa subpopulations. *O. rufipogon* (perennial) and *O. nivara* (annual)are differ from each other based on the morphology and life cycle.

Though, in the course of breeding, this type of traits are generally overlooked or ignored. Variability and distribution of pigmentation in plant canopy can serve as morphological markers in trait mapping and improvement strategies (Maurya et al. 2001). The pigmentation in rice is due to anthocyanin accumulation in the plant which is controlled by many genes. (Reddy 1996), reports say it to be three to five genes involved (Nadaf *et al.,* 1994).

In rice, auricle is known to be an important morphological marker utilized extensively for DUS characterization *per se* varietal identification during the process of seed certification. Most of the rice lines (~82%) harborscolorless auricles (Ahmed *et al.* 2016) In addition, ligules is another important trait in rice reported to be governed by four duplicate additive genes *Lg1*, *Lg2*, *Lg3* and *Lg4* exerts recessive mechanism (Pawar *et al.* 1954 and 1957). Sastry, 1977 has concluded that two recessive genes *(Zg)* were responsible for the liguleless in rice. In another report, Sastry and Seetharaman, 1980 have reported that the absence of ligule is governed by two or three pairs of recessive genes with duplicate or complementary action. In this study they have also reported that liguleless *(/g)* was linked with leaf colour *(Pl).* Pavithran *et al.* (1995) investigated monogenic recessive gene control for the ligulelessness. Tomar *et al.* (2000) reported that presence of normal ligule was dominant over the liguleless trait.

Study of qualitative traits are paramount important for a breeder to know the inheritance pattern of genes and their phenotypic effect which help as morphological markers for varietal identification. Keeping in view we started our research work for identifying the genetics of auricle and ligule colour and their inheritance pattern.

II. MATERIALS AND METHODS

This study pertained to two experiments with eight parents, six F_1s, F_2s and F_3s families (Table 1). The observations for auricle colour (purple and green) were recorded at an early stage of crop. Likewise, data of ligule colour (purple, green and white) was recorded from parents and two breeding families (F_2 and F_3) (Table 2.) representing six crosses for ligule colour (purple, green and white colour) recorded at early stage of crop.

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A. *Field experiment*

The experiment is conducted at the research field of IGKV; Raipur in two years and four consecutive seasons i.e. kharif 2016-17 and Rabi 2017-18. Twenty one days old seedlings were transplanted with 15cm x 15cm spacing. The fertilizer dose of 100 Kg N, 50 Kg P_2O_5 and 50 Kg K_2O per hectare was applied as per recommendation. The nitrogen was applied in three split doses i.e. 40% as basal dose, 30 % at 25 days after transplanting (at active tilling phase) 30% at panicle initiation stage. Entire doses of P_2O_5 and ¾ dose of K_2O were applied as basal dose and remaining potash was applied at PI stage. The crop was maintained as per the standard agronomic practices.

B. *Data collection*

The observations on the parents were recorded on row basis, while F_2 and F_3' population on individual plant basis. for the study of inheritance pattern 172,188,187,159,203 and 168 F_2 populations and 407,513,550,560, 331 and 389 populations were taken from the cross 1, 2, 3, 4, 5 and 6 respectively.

C. *Data analysis*

The data were analysed independently for each trait to determine fitness with diverse segregation ratios in χ2 (Chi-square) test (Fisher, 1936).

$$\chi^2 = \sum_{i=0}^{n} \frac{(E_i^2 - O_i^2)^2}{E_i}$$

Where, O_i = Observed frequency of i^{th} class
E_i= Expected frequency of i^{th} class
(n-1)= degree of freedom
n= number of factors studied

A Goodness of fit test was tested in F_2 and F_3 by using Chi- square test with the help of SAS 9.4. The level of significance for chi-square value was ($P \leq 0.05$).

Sl. No.	Genotype/crosses	Pedigree	Special features	Recommendation for cultivation	Auricle colour	Ligule colour
1	Chandrahasini	Abhaya × Phalguna	High yield potential, export quality grain (non basmatinon-basmati), hence, highly accepted among farmers	Irrigated and rainfedbunded ecosystem of Chhattisgarh.	Green	Green
2	Samleshwari	R 310-37 × R 308-6	High amylose, medium gel consistency, high HRR and desirable ASV.	Direct seeded rainfed-uplands and in rainfedbunded "Matasi" soil of Chhattisgarh	Green	Green
3	Durgeshwari	Mahamaya × NSN 5	Long slender grain, intermediate amylose and gel consistency	Irrigated ecosystem of Chhattisgarh, Odisha and Bihar	Green	Green
4	IC-134022	Landrace	-	-	Green	Light Purple
5	IC-548384	Landrace	-	-	Light Purple	Purple
6	IC-388728	Landrace	-	-	Purple	Green
7	IC-389860	Landrace	-	-	Green	Green
8	IC-390376	Landrace	-	-	Green	

Table 1: Parental description of parental cultivar, its pedigree and features

III. RESULTS

A. *Segregation analysis of auricle colour*

Segregation pattern for auricle colors was analyzed in six families (F_1, F_2 and F_3), results revealed that (how many individual in each generations comes under what trait) were found to have segregation ratio of 15 (Green): 1 (Purple) with χ2 value of 3.28 which fit to duplicate type of digenic epistasis (Table IV and V, Fig. 1). The phenomena of the all studied families (F1, F2 and F3) revealed that auricle colour is governed by two genes.

B. *Inheritance pattern of ligule colour*:

Genetics of purple and green colour character was studied in six crosses segregated into a ratio of 9 (white): 7 (Purple) (Table VI and VII, Fig. 3 and 4). So, the trait is controlled by two major genes.

Auricle colour								
F_2 generation			Purple	Green	White			
IC-548384 × Chandrahasini	Light Purple	Green	5	167	0	0	172	3.28
IC-390376 × Chandrahasini	Green	Green	0	188	0	0	188	12.53**
IC-390376 × Samleshwari	Green	Green	0	187	0	0	187	12.46**
IC-134022 × Durgeshwari	Green	Green	0	159	0	0	159	10.6*
IC-388728 × Chandrahasini	Purple	Green	8	195	0	0	203	1.847
IC-389860 × Samleshwari	Green	Green	0	168	0	0	168	11.2*
Pooled value				177			180	8.65*
F_3 generation								
IC-548384 × Chandrahasini	Light Purple	Green	12	395	0	0	407	7.57*
IC-390376 × Chandrahasini	Green	Green	22	491	0	0	513	3.37
IC-390376 × Samleshwari	Green	Green	29	521	0	0	550	0.90
IC-134022 × Durgeshwari	Green	Green	18	542	0	0	560	8.81*
IC-388728 × Chandrahasini	Purple	Green	35	296	0	0	331	10.56*
IC-389860 × Samleshwari	Green	Green	29	360	0	0	389	0.96
Pooled value				434			458	5.36
Ligule colour								
F_2 generation			Purple	Light purple	Whitish	White /Green		
IC-548384 × Chandrahasini	White	Green	102	0	0	145	247	0.6
IC-390376 × Chandrahasini	Purple	Green	128	0	0	174	302	0.23
IC-390376 × Samleshwari	Purple	Green	159	0	0	186	345	0.77
IC-134022 × Durgeshwari	Purple	Green	137	0	0	159	296	0.77
IC-388728 × Chandrahasini	Purple	Green	164	0	0	195	359	0.54
IC-389860 × Samleshwari	Purple	Green	128	0	0	168	296	0.03
Pooled value			136			171	308	0.49
F_3 generation								
IC-548384 × Chandrahasini	White	Green	140	0	0	165	305	0.57
IC-390376 × Chandrahasini	Purple	Green	175	0	0	205	380	0.82
IC-390376 × Samleshwari	Purple	Green	159	0	0	220	379	0.5
IC-134022 × Durgeshwari	Purple	Green	198	0	0	242	440	0.28
IC-388728 × Chandrahasini	Purple	Green	245	0	0	291	536	0.84
IC-389860 × Samleshwari	Purple	Green	190	0	0	239	429	0.05
Pooled value			185			227	412	0.51

Table 2: Inheritance pattern of auricle and ligule colour

(*) Significantly deviated at 0.05 ($\chi 2$ *(t)*= 7.81 for F2 and F3), (**) significantly deviated at 0.01 ($\chi 2$ *(t)* = 11.34 for F2 and F3; P1=parent one and P2-parent two

IV. DISCUSSION

Segregation of monogenic traits follows the Mendelian pattern. The study of the segregation pattern of these Mendelian traits is very important to characterize, identification and genetics of qualitative traits. The advantage of study of qualitative traits includes varietal identification during seed certification.

For the study of auricle colour eight parents (Chandrahasini, Samleshwari, Durgeshwari, IC-548384, IC-388728, IC-IC-390376, IC-134022 and IC-389860) used it. Different crosses (IC-548384 × Chandrahasini, IC-390376 × Chandrahasini, IC-390376 × Samleshwari, IC-134022 × Durgeshwari, IC-388728 × Chandrahasini, IC-389860 × Samleshwari) were made and segregation pattern was studied in the F_2 and F_3 population. Based on the $\chi 2$ analysis, in the cross IC-548384 × Chandrahasini, the F_2 and F_3 population exhibited a ratio of 15 (Green): 1 (Purple) (F_2, $\chi 2$ = 3.28 and F_3, c= 7.57) as the calculated value of $\chi 2$ is smaller than the table value which indicates that the observed and expected frequencies are in close agreement and little deviation of result may be due to the chance or probability factor and the gene is governed by two genes with a duplicate gene action (Ahmed *et al.*, 2016).

Ligule colour is another important trait for inheritance study for which we have taken eight parents (Chandrahasini, Samleswari, Durgeswari, IC-548384, IC-388728, IC-IC-390376, IC-134022 and IC-389860) and made six different crosses (IC-548384 × Chandrahasini, IC-390376 × Chandrahasini, IC-390376 × Samleshwari, IC-134022 × Durgeshwari, IC-388728 × Chandrahasini, IC-389860 × Samleshwari). In F_2 population, $\chi 2$ values for the crosses IC-548384 × Chandrahasini, IC-390376 × Chandrahasini, IC-390376 × Samleshwari, IC-134022 × Durgeshwari, IC-

388728 × Chandrahasini and IC-389860 × Samleshwari were 0.6, 0.23, 0.77, 0.77, 0.54 and 0.03 respectively.

In F_3 population, $\chi 2$ values for the crosses IC-548384 × Chandrahasini, IC-390376 × Chandrahasini, IC-390376 × Samleshwari, IC-134022 × Durgeshwari, IC-388728 × Chandrahasini and IC-389860 × Samleshwari. The F_2 and F_3 population of IC-548384 × Chandrahasini, IC-390376 × Chandrahasini, IC-390376 × Samleshwari, IC-134022 × Durgeshwari, IC-388728 × Chandrahasini and IC-389860 × Samleshwari were 0.57, 0.82, 0.50, 0.28, 0.84 and 0.05 respectively.

Both the F_2 and F_3 exhibited a non-significance $\chi 2$-value which indicates a close agreement between observed and expected frequencies and the deviation may be due to chance factor only. Above all the six crosses, F_2 and F_3 population exhibited a ratio of 9 (white): 7 (Purple) (Ghose *et al.,* 1957) which indicates the ligule trait is governed by two major genes (Sastry, 1977) and a 9:7 indicates complementary gene action.

V. CONCLUSION

Auricle and ligule colour are the qualitative characters that can be used as morphological markers for varietal identification especially in major cerealcrops like rice. In our study the auricle colour is governed by two major genes and segregated in 15:1 ratio with duplicate gene action and the ligule colour is segregated in the ratio 9;7 which is governed by two major genes having complementary gene action. Many times, these traits are related with different biotic and abiotic stress traits, so these traits have significant implications for futurebreeding programs. From a breeding standpoint, identifying the inheritance pattern of these traits remains an essentialgoal to realizing the potential of agricultural research and innovation. In this respect, blending of morphological- and molecular-based approaches will help to identify tightly linked characters. All these essential perspectives should enable us tostudy the inheritance pattern of auricle and ligule colour.

VI. ABBREVIATIONS

IC: Indigenous collection, *Lg*: Ligule, SAS: Statistical analysis System, F_2: second Filial Generation, F_3: Third Filial Generation, HRR: Head rice recovery, ASV: Alkali spreading value.

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