Indian J. Genet., **55** (4): 351–356 (1995)

GENETIC STUDIES IN RICE (*ORYZA SATIVA* L.): INHERITANCE OF FOUR SPIKELET CHARACTERS

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(Received: October 24, 1992; accepted: June 9, 1995)

ABSTRACT

Inheritance of four spikelet characters, viz., anthocyanin pigmentation in lemma/palea, red awn, black hull and awning (awn formation) was studied in a cross between two upland rice cultivars, namely, D 6-2-2 (green variety) and HY-256 Purple (purple variety). Purplish black zones in lemma/palea, red awn and black hull characters behaved as recessive and each segregated into a hexagenic ratio of 3 : 4093 for their presence vs. absence with the involvement of one basic gene for the character expression and five inhibitory duplicate genes, while awning which also behaved as a recessive trait was under the control of five genes, of which one was basic and the other four were inhibitory duplicate genes to give a genetic ratio of 3 : 1021 for presence vs. absence of awns. Each of these characters was monogenic dominant in the absence of the inhibitory genes.

Key words: *Oryza sativa* L., rice, lemma/palea, hull, awn, pigmentation, inheritance.

Various genetic studies in rice conducted earlier revealed the existence of inhibitory genes for the expression of the characters associated particularly with wild and weedy species of *Oryza* like pigmentation, black hull, red awn, awning etc. [1–5]. These inhibitory genes perhaps ensure the wild type characters to be unexposed in the cultivated rice populations. Therefore, the present study has been undertaken to understand the inheritance of four spikelet characters, viz. purplish black zones in lemma / palea, black hull, red awn and awning as these were not expressed in either of the parents and F_1 of a cross.

MATERIALS AND METHODS

Inheritance of four spikelet characters, viz. purplish black zones in lemma/palea, showing uneven distribution of broad black zones in purple background of lemma / palea, which are quite different from either purple spreading, purple piebald or purple mottling expressions, black hull, red awn and awning, was studied in a cross between two upland cultivars, namely, D 6-2-2 (green variety, devoid of pigmentation on any of its plant parts) and HY-256 Purple (purple variety, pigmented in most of its parts with full purple leaf blade) at the Agricultural Research Station, Mugad, Dharwad, Karnataka, during 1987–1989. A total of 50 plants in each parent, 30 plants of F_1, 2458 plants of F_2 generation, and 114 F_3 families (each having 74–100 plants) were used to record observations on the presence or absence of these characters. The goodness of assumed genetic ratios in F_2 and F_3 breeding behaviour was tested by χ^2 tests. The gene symbols recommended by the International Rice Commission [6] were used.

RESULTS AND DISCUSSION

Table 1 presents the phenotypes of parents, F_1 and F_2 as well as segregation in F_2 for four spikelet characters, viz., purplish black zones in lemma/palea, black hull, red awn, and awning. These characters appeared in low frequency in the F_2 generation and could be suspected to be either segregates or mutants. The number of F_2 plants with the lemma/palea

Table 1. Inheritance of four spikelet characters in the cross D 6-2-2 x HY-256 Purple of rice

Character	Parent phenotype		F_1	Expected ratio	O/E	F_2 frequency		χ^2	P
	D 6-2-2	HY-256 Purple				+	-		
Lemma/palea pigmentation	—	—	—		O	2.0	2456		
				3:4093	E	1.8	2456	0.022	0.90–0.80
Red awn	—	—	—		O	1.0	2457		
				3:4093	E	1.8	2456	0.356	0.70–0.50
Black hull	—	—	—		O	1.0	2457		
				3:4093	E	1.8	2456	0.356	0.70–0.50
Awning	—	—	—		O	11.0	2447		
				3:1021	E	7.2	2451	2.011	0.20–0.10

+/– indicate presence/absence of pigmentation in lemma/palea and presence/absence of red awn, black hull and awning.

having purplish black zones, black hull, red awn and awning were 2, 1, 1 and 11, respectively. The F_2 frequency was 8×10^{-4} for pigmentation in lemma/palea, 4×10^{-4}, for black hull and red awn, and 4×10^{-3} for awning. In the 114 F_3 families comprising 10386 plants, 11 F_3 plants with purplish black zones in their lemma/palea gave a frequency of about 10^{-3}, three plants with black hull was the frequency of about 3×10^{-4}, and 26 plants with full awns was 2.5×10^{-3} regardless of the families. Red awned plants were, however, not observed in F_3 generation. Almost similar frequencies of these four spikelet characters in both F_2 and F_3 generations compel us to treat them as segregates, whose low frequency agrees with the hypotheses based on the assumption of 4–5 pairs of inhibitors with the basic gene responsible for the expressions of each of these characters since inhibitors are not uncommon in rice [1–5]. These new phenotypes with such low frequencies could possibly be detected in both F_2 and F_3 generations because of their large population size. However, in the absence of information on mutation rates for each of these characters, it is difficult to explain the appearance of these rare characters on the basis of segregation alone.

Rare occurrence of these characters in F_2 prompted us to treat the plants having these characters as critical plants. They were harvested panicle-wise separately and the seeds of five random panicles were sown separately to test their breeding behaviour (Table 2). It was interesting that all these characters were monogenic dominant.

Table 2. Breeding behaviour of F_2 plants with respect to new characters in F_3 generation based on monogenic inheritance

Panicle progeny	Rare character combinations observed in F_2											
	lemma/palea coloured (3:4093)			red awn (3:4093)			black hull (3:4093)			awning (3:1012)		
	+	–	χ^2	+	–	χ^2	+	–	χ^2	+	–	χ^2
Panicle 1	38	13	0.006	30	11	0.073	44	16	0.089	46	15	0.005
Panicle 2	42	18	0.800	41	14	0.006	36	16	0.923	37	12	0.007
Panicle 3	46	17	0.132	38	10	0.444	40	13	0.006	40	12	0.103
Panicle 4	46	19	0.621	35	13	0.111	31	11	0.032	44	20	1.333
Panicle 5	48	14	0.194	40	12	0.103	42	16	0.207	44	14	0.023
Total	220	81	0.586	184	60	0.022	193	72	0.665	211	73	0.075
	χ^2	d.f.	P	χ^2	d.f.	P	χ^2	d.f.	P	χ^2	d.f.	P
Deviation	0.586	1	0.50–0.30	0.022	1	0.90–0.80	0.665	1	0.50–0.30	0.075	1	0.80–0.70
Heterogeneity	1.167	4	0.90–0.80	0.715	4	0.95–0.90	0.592	4	0.98–0.95	1.396	4	0.90–0.80
Total	1.753	5	0.90–0.80	0.737	5	0.99–0.98	1.257	5	0.95–0.90	1.471	5	0.95–0.90

The characters purplish black zones in lemma/palea, red awn and black hull segregated into 3 : 4093 for presence and absence of the respective traits, which can be explained by assuming one basic gene for the expression of the character and five inhibitory duplicate genes. Awning was under the control of five genes, of which one was basic and four inhibitory duplicate, as shown by the pentagenic ratio of 3 : 1021 for presence vs. absence of awning.

Based on the established genetic hypotheses, the genotypic constitution of the parents for the various characters can be derived as follows:

Character	D 6-2-2	HY-256 Purple
Purplish black zones in lemma/palea	prpr i-Pr_1 i-Pr_1 i-Pr_2 i-Pr_2 i-Pr_3 i-Pr_3 i-Pr_4 i-Pr_4 i-Pr_5 i-Pr_5	PrPr I-Pr_1 I-Pr_1 I-Pr_2 I-Pr_2 I-Pr_3 I-Pr_3 I-Pr_4 I-Pr_4 I-Pr_5 I- Pr_5
Red awn	ran ran i-Ran_1 i-Ran_1 i-Ran_2 i-Ran_2 i-Ran_3 i-Ran_3 i-Ran_4 i-Ran_4 i-Ran_5 i-Ran_5	Ran Ran I-Ran_1 I-Ran_1 I-Ran_2 I-Ran_2 I-Ran_3 I-Ran_3 I-Ran_4 I-Ran_4 I-Ran_5 I-Ran_5
Black hull	bh bh i-Bh_1 i-Bh_1 i-Bh_2 i-Bh_2 i-Bh_3 i-Bh_3 i-Bh_4 i-Bh_4 i-Bh_5 i- Bh_5	Bh Bh I-Bh_1 I-Bh_1 I-Bh_2 I-Bh_2 I-Bh_3 I-Bh_3 I-Bh_4 I-Bh_4 I-Bh_5 I- Bh_5
Awning	an an i-An_1 i-An_1 i-An_2 i-An_2 i-An_3 i-An_3 i-An_4 i-An_4	An An I-An_1 I-An_1 I-An_2 I-An_2 I-An_3 I-An_3 I-An_4 I-An_4

Monogenic inheritance of lemma/palea colour has been reported by many workers [7–9]. Inhibitory genes for lemma/palea pigmentation were also detected in the past [10–13]. Black hull coloration was reported to be controlled by one dominant gene [11, 15]. However, inhibitors for this character were not reported earlier. For awn colour, monogenic inheritance (dominant) was observed [16–19] but inhibitory genes for awn colour were not reported. Monogenic dominant nature of awning was observed by many workers [20–24], while others reported existence of inhibitory genes for this character [25–28].

Thus, one basic gene for each of the spikelet characters was conclusively proved by the breeding behaviour of the panicle progenies of the F_2 plants showing these characters. This led to the conclusion that the two parents differed not only for the basic gene but also for 4–5 additional inhibitors loci capable of inhibiting the development of these characters independently.

ACKNOWLEDGEMENT

The first author is grateful to the ASPEE Agricultural Research and Development Foundation, Bombay, for a fellowship.

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