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Studies on pleiotropy in rice, *Oryza sativa* L.: X-ray induced transformation of genetic control and pleiotropic relationships of morphological characters

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ABSTRACT

A normal cross between Cherumodan and Japan Violet as control and three differential crosses of the same parents, wherein 1500, 2000 and 5000 rads X-ray treated pollen grains were used for pollination, were studied upto F_3/M_3F_3 generations for the analysis of possible genetical transformations. The results showed transformation of ratios for inheritance and of interrelationships of morphological characters of which the pleiotropic associations are dealt with here.

Key words: *Genetical analysis, X-rayed pollen grain, transformation, pleiotropy, rice*

The complexity of rice genetic system is generally attributed to differential patterns of intricate gene interactions, linkage relationships and pleiotropic control of morphological characters, existence of multiple alleles and polygenes. Pleiotropic genes are common in rice and it has been estimated to be nearly 10% of the total genes known in rice (Anitha 1994, Pavithran 2005). The present study refers to the induced alteration/ transformation of pleiotropic associations in certain differential crosses wherein pollen grains X-rayed with different dosages were used for pollination.

MATERIALS AND METHODS

The materials used are Cherumodan (@&)and Japan Violet (B&) with 80- 85 and 90-95 days duration respectively. The female parent has all plant parts green except leaf axil and the male parent is a purple marker for anthocyanin pigment with tip-sterility. The crosses studied are Ch x JV (normally pollinated as control), Ch x JV (pollinated with 1500 rads X-ray treated pollen grains), Ch x JV (pollinated with 2000 rads X-ray treated pollen grains) and Ch x JV (pollinated with 5000 rads X-ray treated pollen grains). The crosses were studied up to the respective F_3/M_3F_3 generations under uniform conditions of culture (Santhoshlal and Pavithran 2006).

The expectant spikelets of Japan Violet were exposed to X-ray (Pandey 1978, 1983) emitting @ 420 rads/min with the help of Maximar-100 of the Medical College, Calicut. The dosages were calibrated to 1500, 2000 and 5000 rads. Pollen grains collected from the irradiated spikelets were dusted over the stigmatic lobes of the respective pre-emasculated flowers of the female parent during 8-9 a.m. The plants were kept at the Medical College, Calicut for a few days and then transferred to net house of the Calicut University. Seeds were harvested at 30 day maturity and were grown for F_1/M_1F_1 generation. During subsequent seasons F_2/M_2F_2 and F_3/M_3F_3 generations were studied following Misro (1963).

Both for individual segregations and interrelationships of morphological characters, Chi-square tests were applied for goodness of fit (Richharia *et al.*, 1966) and wherever joint Chi-square showed higher values, but did not yield any linkage relationships, pleiotropy was assumed and Chisquare test for goodness of fit was applied on expected pleiotropic ratio to determine pleiotropy

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RESULTS AND DISCUSSION

Data on differential patterns of inheritance of morphological characters and their transformed genic interrelationships relating to pleiotropy are presented in Tables 1 and 2 respectively. Transformation of genetical ratios mostly showed different complementary loci for the expression of the concerned characters (Table I). Pleiotropic association of morphological characters mostly showed linear increase of such instances with increase in dosage of X-ray treatments except for *Px* and *Pn*. Consistently, pleiotropic association of morphological characters increasingly occurred in the treated crosses from 30 (control) to 32 in 1500 rads treated cross, to 37 in 2000 rads treated cross and to 45 in 5000 rads treated cross (Table 2). The pleiotropic relationships were invariably broken with 5000 rads treatment in relation to *Px—Psh/Plm/P1/Pla/Pjp/Plg/Pau/Pin/Ps/Pa, Pn—Pin/Ps/Pa/P 1 /Plg/Pau* (Table 2). No pleiotropic association of any character was observed with an and tst in crosses 1-4. Similarly, no change/transformation occurred with pleiotropic associations of *Pl—Pau/Ps/Pa*, *Pjp-Pin/Ps/Pa*, *Plg—Ps/Pa* and *Pau—Ps* in the control (Table 2). New pleiotropic associations of certain characters were formed with 5000 rads treated cross. These are *Psh—P1/Plm/Pla/Pjp/Plg/Pau/Pin/Ps/Pa*,*P1--Pjp/Plg/Pau, Plm—Pla/Pjp/Plg/Pau/Pin/Ps/Pa, Pla—Pjp/Plg/Pau/Pin/Ps/Pa, Pjp—Plg/Pau. Plg—Pau, Pin—Ps/Pa* and *Ps—Pa* (Table 2). However, in the case of *P1—Pjp, Plm—Pjp/Pau/Ps* and *Pjp—Plg* all the treated crosses produced pleiotropic associations compared to the control. These transformations in the genic interrelationships might have occurred, probably, due to chromosomal aberrations and certain consequential rearrangements induced by the X-ray treatments of the pollen grains used for hybridization.

It is difficult to distinguish tight linkage from pleiotropy due to complete absence of recombinant classes (Misro 1968, 1981). Misro has suggested effective irradiation as a test for pleiotropy/tight linkage. It has been estimated earlier that over 650 genes have been identified in rice to have control over 200 characters (Pavithran 1986, Kinoshita 1991, 1993) and also that over 10% of those genes have been estimated to have pleiotropic control over different morphological characters (Anitha 1994, Pavithran 2005). Kinoshita

Table 1. Inheritance of morphological characters in relation to genetical transformation induced by X-ray treated pollen grain used in crosses of Cherumodan X Japan Violet

				F_2/M_2F_2 of Crosses							
Morph.	Parents			1		2		3		4	
Characters	♀	♂	F_1/M_1F_1 in all crosses	F_2/M_2F_2 population P-G	Ratio	F_2/M_2F_2 population P-G	Ratio	F_2/M_2F_2 population P-G	Ratio	F_2/M_2F_2 population P-G	Ratio
Leaf axil	+	+	+/+	132/12	15:1	171/10	15:1	70/6	15:1	36/2	15:1
Node	-	-	--/-	30/114	3:13	25/156	3:13	16/60	3:13	7/31	3:13
Awn	-	+	+/+	107/37	3:1	128/53	3:1	61/15	3:1	27/11	3:1
Tip sterility	-	+	+/+	107/37	3:1	144/37	3:1	57/19	3:1	33/5	3:1
Leaf sheath	-	+	+/+	111/33	3:1	126/55	3:1	55/21	3:1	23/15	9:7
Leaf margin	-	+	+/+	100/44	3:1	114/67	9:7	49/27	9:7	19/19	9:7
Leaf tip	-	+	+/+	103/41	3:1	114/67	9:7	53/23	3:1	20/18	9:7
Internode	-	+	+/+	106/38	3:1	126/55	3:1	54/22	3:1	22/16	9:7
Stigma	-	+	+/+	108/36	3:1	138/43	3:1	54/22	3:1	22/16	9:7
Apiculus	-	+	+/+	106/38	3:I	127/54	3:1	55/21	3:1	22/16	9:7
Leafblade	-	+	+/+	82/62	9:7	93/88	9:7	38/38	27:37	14/24	27:37
Junctura Proper	-	+	+/+	75/69	9:7	80/101	27:37	33/43	27:37	15/23	27:37
Ligule	-	+	+/+	89/55	9:7	102/79	9:7	39/37	9:7	15/23	27:37
Auricle	-	+	+/+	77/67	9:7	89/92	27:37	33/43	27:37	12/26	27:37

P - Purple
G - Green
+ - Presence
- - Absence

1. Normal cross
2. 1500 rads treated pollen
3. 2000 rads treated pollen
4. 5000 rads treated pollen

Table 2. Interrelationship of morphological characters studied for pleiotropic relationship of gametes in crosses 1-4

Character Combination			Cross/es	Population	Joint F_2 Frequency				Total	X^2 on P	P Value
F_2 ratio /s					AB	Ab	aB	ab			
Px	Vs	Psh									
(15:1)		(3:1)	1	0	111.00	21.00	0.00	12.00	144.00	2.42	0.50 -0.30
(15:1)	Vs	(3:1)	2	0	126.00	45.00	0.00	10.00	181.00	4.46	0.30-0.20
(15:1)	Vs	(3:1)	3	0	55.00	15.00	0.00	6.00	76.00	0.44	0.95-0.90
Px	Vs	Plm									
(15:1)		(3:1)	1	0	100.00	32.00	0.00	12.00	144.00	2.52	0.50-0.20
(15:1)	Vs	(9:7)	2	0	114.00	57.00	0.00	10.00	181.00	3.36	0.50-0.20
(15:1)	Vs	(9:7)	3	0	49.00	21.00	0.00	6.00	76.00	3.21	0.50-0.30
Px	Vs	PI									
(15:1)		(9:7)	1	0	82.00	50.00	0.00	12.00	144.00	1.31	0.80 -0.70
(15:1)	Vs	(9:7)	2	0	93.00	78.00	0.00	10.00	181.00	2.42	0.50 -0.30
Px	Vs	Pla									
(15:1)		(3:1)	1	0	103.00	29.00	0.00	12.00	144.00	1.38	0.80-0.70
(15:1)	Vs	(9:1)	2	0	114.00	57.00	0.00	10.00	181.00	3.05	0.50 -0.30
(15:1)	Vs	(3:1)	3	0	53.00	17.00	0.00	6.00	76.00	1.14	0.80-0.70
Px	Vs	Pjp									
(15:1)		(9:7)	1	0	75.00	57.00	0.00	12.00	144.00	1.61	0.70 -0.50
Px	Plg										
(15:1)		(9:7)	1	0	89.00	43.00	0.00	12.00	144.00	4.03	0.30 -0.20
(15:1)	Vs	(9:7)	2	0	102.00	69.00	0.00	10.00	181.00	0.17	0.99-0.95
Px	Vs	Pau									
(15:1)		(9:7)	1	0	77.00	55.00	0.00	12.00	144.00	1.22	0.80-0.70
Px	Vs	Pin									
(15:1)		(3:1)	1	0	106.00	26.00	0.00	12.00	144.00	1.08	0.80 - 0.70
(15:1)	Vs	(3:1)	2	0	126.00	45.00	0.00	10.00	181.00	4.46	0.30 - 0.20
(15:1)	Vs	(3:1)	3	0	54.00	16.00	0.00	6.00	76.00	0.70	0.90-0.80
Px	Vs	Ps									
(15:1)		(3:1)	1	0	108.00	24.00	0.00	12.00	144.00	1.33	0.80 -0.70
(15:1)	Vs	(3:1)	2	0	138.00	33.00	0.00	10.00	181.00	0.22	0.98-0.95
(15:1)	Vs	(3:1)	3	0	54.00	16.00	0.00	6.00	76.00	0.70	0.90-0.80
Px	Vs	Pa									
(15:1)		(3:1)	1	0	106.00	26.00	0.00	12.00	144.00	1.08	0.80-0.70
(15:1)	Vs	(3:1)	2	0	127.00	44.00	0.00	10.00	181.00	3.70	0.50-0.30
(15:1)	Vs	(3:1)	3	0	55.00	15.00	0.00	6.00	76.00	0.44	0.95-0.90
Psh	Vs	PI									
(9:7)		(27:37)	4	0	14.00	9.00	0.00	15.00	38.00	2.92	0.50-0.30
Psh	Vs	Plm									
(3:1)		(9:7)	3	0	49.00	6.00	0.00	21.00	76.00	5.90	0.20-0.10
(9:7)	Vs	(9:7)	4	0	19.00	4.00	0.00	15.00	38.00	7.46	0.10-0.05
Psh	Vs	Pla									
(9:7)		(9:7)	4	0	19.00	4.00	0.00	14.00	38.00	5.07	0.20-0.10
Psh	Vs	Pjp									
(9:7)		(27:37)	4	0	15.00	8.00	0.00	15.00	38.00	1.55	0.70-0.50
Psh	Vs	Plg									
(9:7)		(27:37)	4	0	15.00	8.00	0.00	15.00	38.00	1.55	0.70-0.50
Psh	Vs	Pau									
(9:7)		(27:37)	4	0	12.00	11.00	0.00	15.00	38.00	7.17	0.10-0.05
Psh	Vs	Pin									
(9:7)		(9:7)	4	0	21.00	2.00	1.00	14.00	38.00	7.81	0.10-0.05

Psh	Vs	Ps									
(9:7)		(9:7)	4	0	21.00	2.00	1.00	14.00	38.00	7.81	0.10-0.05
Psh	Vs	Pa									
(9:7)		(9:7)	4	0	21.00	2.00	1.00	14.00	38.00	7.81	0.10-0.05
Pl	Vs	Plm									
(9:7)		(3:1)	1	0	82.00	0.00	18.00	44.00	144.00	4.79	0.20-0.10
(9:7)	Vs	(9:7)	3	0	38.00	0.00	11.00	27.00	76.00	2.28	0.70-0.50
(27:37)	Vs	(9:7)	4	0	14.00	0.00	5.00	19.00	38.00	0.62	0.90-0.80
PI	Vs	Pla									
(9:7)		(3:1)	1	0	82.00	0.00	21.00	41.00	144.00	2.04	0.70-0.50
(27:37)	Vs	(9:7)	3	0	38.00	0.00	15.00	23.00	76.00	5.90	0.20-0.10
(27:37)	Vs	(9:7)	4	0	14.00	0.00	6.00	18.00	38.00	0.71	0.90-0-80
PI	Vs	Pjp									
(9:7)		(27:37)	2	0	80.00	13.00	0.00	88.00	181.00	7.04	0.10-0.05
(27:37)	Vs	(27:37)	3	0	30.00	8.00	3.00	35.00	76.00	4.64	0.30-0.20
(27:37)	Vs	(27:37)	4	0	11.00	3.00	4.00	20.00	38.00	0.57	0.95-0.90
PI	Vs	Plg									
(27:37)	Vs	(9:7)	3	0	38.00	0.00	3.00	36.00	76.00	6.85	0.10-0.05
(27:37)	Vs	(27:37)	4	0	12.00	2.00	3.00	21.00	38.00	1.77	0.70-0.50
PI	Vs	Pau									
(27:37)	Vs	(27:37)	3	0	31.00	7.00	2.00	36.00	76.00	6.66	0.10-0.05
(27:37)	Vs	(27:37)	4	0	10.00	4.00	2.00	22.00	38.00	2.26	0.70-0.50
Pl	Vs	Pn									
(9:7)	Vs	(3:13)	1	0	26.00	56.00	4.00	58.00	144.00	3.18	0.50-0.30
(9:7)	Vs	(3:13)	2	0	22.00	71.00	3.00	85.00	181.00	7.27	0.10-0.05
(27:37)	Vs	(3:13)	3	0	12.00	26.00	4.00	34.00	76.00	3.30	0.50-0.30
Pl	Vs	Pin									
(9:7)		(3:1)	1	0	82.00	0.00	24.00	38.00	114.00	0.04	0.95-0.90
(9:7)		(3:1)	2	0	93.00	0.00	33.00	55.00	181.00	2.89	0.50-0.30
(27:37)		(3:1)	3	0	38.00	0.00	16.00	22.00	76.00	4.78	0.20-0.10
(27:37)		(9:7)	4	0	14.00	0.00	8.00	16.00	38.00	1.61	0.70 - 0.50
PI	Vs	Ps									
(9:7)	Vs	(3:1)	1	0	82.00	0.00	26.00	36.00	144.00	0.08	0.98
(9:7)	Vs	(3:1)	2	0	93.00	0.00	45.00	43.00	181.00	4.48	0.30-0.20
(27:37)	Vs	(3:1)	3	0	38.00	0.00	16.00	22.00	76.00	4.78	0.20-0.10
(27:37)	Vs	(9:7)	4	0	14.00	0.00	8.00	16.00	38.00	1.61	0.70 - 0.50
PI	Vs	Pa									
(9:7)	Vs	(3:1)	1	0	82.00	0.00	24.00	38.00	144.00	0.75	0.90 - 0.80
(9:7)	Vs	(3:1)	2	0	93.00	0.00	34.00	54.00	181.00	2.26	0.70 - 0.50
(27:37)	Vs	(3:1)	3	0	38.00	0.00	17.00	21.00	76.00	3.84	0.30 - 0.20
(27:37)	Vs	(9:7)	4	0	14.00	0.00	8.00	16.00	38.00	1.61	0.70 -0.50
Plm	Vs	Pla									
(9:7)	Vs	(9:7)	2	0	114.00	0.00	0.00	67.00	181.00	3.34	0.50-0.30
(9:7)	Vs	(9:7)	4	0	17.00	2.00	3.00	16.00	38.00	5.15	0.20-0.10
Plm	Vs	Pjp									
(9:7)	Vs	(27:37)	2	0	80.00	34.00	0.00	67.00	181.00	4.92	0.20-0.10
(9:7)	Vs	(27:37)	3	0	33.00	16.00	0.00	27.00	76.00	3.84	0.30-0.20
(9:7)	Vs	(27:37)	4	0	15.00	4.00	0.00	19.00	38.00	0.74	0.90-.0.80
Plm	Vs	Plg									
(9:7)	Vs	(27:37)	4	0	15.00	4.00	0.00	19.00	38.00	0.74	0.90-0.80
Plm	Vs	Pau									
(9:7)	Vs	(27:37)	2	0	89.00	25.00	0.00	67.00	181.00	3.98	0.30-0.20
(9:7)	Vs	(27:37)	3	0	33.00	16.00	0.00	27.00	76.00	3.84	0.30-0.20
(9:7)	Vs	(27:37)	4	0	12.00	7.00	0.00	19.00	38.00	1.87	0.70 -0.50

Plm	Vs	Pn									
(9:7)	Vs	(3:13)	2	0	21.00	93.00	4.00	63.00	181.00	7.61	0.10-0.05
(9:7)	Vs	(3:13)	3	0	16.00	33.00	0.00	27.00	76.00	2.47	0.50 - 0.30
Plm	Vs	Pin									
(9:7)	Vs	(3:1)	3	0	49.00	0.00	5.00	22.00	76.00	7.39	0.10-0.05
(9:7)	Vs	(9:7)	4	0	17.00	2.00	5.00	14.00	38.00	2.75	0.50 - 0.30
Plm	Vs	Ps									
(9:7)	Vs	(3:1)	2	0	114.00	0.00	24.00	43.00	181.00	4.48	0.30-0.20
(9:7)	Vs	(3:1)	3	0	49.00	0.00	5.00	22.00	76.00	7.39	0.10-0.05
(9:7)	Vs	(9:7)	4	0	17.00	2.00	5.00	14.00	38.00	0.77	0.90 -0.80
Plm	Vs	Pa									
(9:7)	Vs	(3:1)	3	0	49.00	0.00	6.00	21.00	76.00	5.90	0.20 -0.10
(9:7)	Vs	(9:7)	4	0	17.00	2.00	5.00	14.00	38.00	2.82	0.50 -0.30
Pla	Vs	Pjp									
(9:7)	Vs	(27:37)	2	0	80.00	34.00	0.00	67.00	181.00	4.92	0.20 -0.10
(9:7)	Vs	(27:37)	4	0	15.00	5.00	0.00	18.00	38.00	0.20	0.00 -0.95
Pla	Vs	Plg									
(9:7)	Vs	(27:37)	4	0	15.00	5.00	0.00	18.00	38.00	0.20	0.00 - 0.95
Pla	Vs	Pau									
(9:7)	Vs	(27:37)	4	0	12.00	8.00	0.00	18.00	38.00	2.45	0.50 - 0.30
Pla	Vs	Pn									
(9:7)	Vs	(3:13)	2	0	21.00	93.00	4.00	63.00	181.00	7.60	0.10 -0.05
Pla	Vs	Pin									
(9:7)	Vs	(9:7)	4	0	18.00	2.00	4.00	14.00	38.00	3.32	0.5-0.30
Pla	Vs	Ps									
(9:7)	Vs	(3:1)	2	0	114.00	0.00	24.00	43.00	181.00	4.48	0.30-0.20
(9:7)	Vs	(9:7)	4	0	18.00	2.00	4.00	14.00	38.00	3.32	0.50 -0.30
Pla	Vs	Pa									
(9:7)	Vs	(9:7)	4	0	19.00	1.00	3.00	15.00	38.00	6.32	0.10 - 0.05
Pjp	Vs	Plg									
(27:37)	Vs	(9:7)	2	0	80.00	0.00	22.00	79.00	181.00	0.64	0.90 -0.80
(27:37)	Vs	(9:7)	3	0	33.00	0.00	6.00	37.00	76.00	2.78	0.50 -0.30
(27:37)	Vs	(27:37)	4	0	11.00	4.00	4.00	19.00	38.00	0.15	0.99 -0.98
Pjp	Vs	Pau									
(27:37)	Vs	(27:37)	4	0	11.00	4.00	1.00	22.00	38.00	3.25	0.50 -0.30
Pjp	Vs	Pn									
(27:37)	Vs	(3:13)	2	0	20.00	60.00	5.00	96.00	181.00	7.14	0.10 - 0.05
(27:37)	Vs	(3:13)	3	0	12.00	21.00	4.00	39.00	76.00	3.21	0.50-0.30
Pjp	Vs	Pin									
(9:7)	Vs	(3:1)	1	0	75.00	0.00	31.00	38.00	144.00	1.15	0.80-0.70
(27:37)	Vs	(3:1)	2	0	80.00	0.00	46.00	55.00	181.00	5.29	0.20-0.10
(27:37)	Vs	(3:1)	3	0	33.00	0.00	21.00	22.00	76.00	1.12	0.80-0.70
(27:37)	Vs	(9:7)	4	0	15.00	0.00	7.00	16.00	38.00	0.61	0.90-0.80
Pjp	Vs	Ps									
(9:7)	Vs	(3:1)	1	0	75.00	0.00	33.00	36.00	144.00	1.78	0.70-0.50
(27:37)	Vs	(3:1)	2	0	80.00	0.00	58.00	43.00	181.00	0.32	0.98-0.95
(27:37)	Vs	(3:1)	3	0	33.00	0.00	21.00	22.00	76.00	1.12	0.80-0.70
(27:37)	Vs	(9:7)	4	0	15.00	0.00	7.00	16.00	38.00	0.61	0.90-0.80
Pjp	Vs	Pa									
(9:7)	Vs	(3:1)	1	0	75.00	0.00	31.00	38.00	144.00	1.15	0.80-0.70
(27:37)	Vs	(3:1)	2	0	80.00	0.00	47.00	54.00	181.00	4.44	0.30-0.20
(27:37)	Vs	(3:1)	3	0	33.00	0.00	22.00	21.00	76.00	0.58	0.95-0.90
(27:37)	Vs	(9:7)	4	0	15.00	0.00	7.00	16.00	38.00	0.61	0.90-0.80

Plg	Vs	Pau									
(9:7)	Vs	(27:37)	3	0	33.00	6.00	0.00	37.00	76.00	2.51	0.50-0.30
(27:37)	Vs	(27:37)	4	0	10.00	5.00	2.00	21.00	38.00	2.11	0.70-0.50
Plg	Vs	Pn									
(9:7)	Vs	(3:13)	1	0	26.00	63.00	4.00	51.00	144.00	3.33	0.50-0.30
(9:7)	Vs	(3:13)	2	0	22.00	80.00	3.00	76.00	181.00	4.58	0.30-0.20
Plg	Vs	Pin									
(9:7)	Vs	(3:1)	1	0	89.00	0.00	17.00	38.00	144.00	4.61	0.30-0.20
(9:7)	Vs	(3:1)	3	0	39.00	0.00	15.00	22.00	76.00	0.84	0.90-0.80
(27:37)	Vs	(9:7)	4	0	15.00	0.00	7.00	16.00	38.00	0.61	0.90-0.80
Plg	Vs	Ps									
(9:7)	Vs	(3:1)	1	0	89.00	0.00	19.00	36.00	144.00	3.16	0.50-0.30
(9:7)	Vs	(3:1)	2	0	102.00	0.00	36.00	43.00	181.00	0.24	0.00-0.95
(9:7)	Vs	(3:1)	3	0	39.00	0.00	15.00	22.00	76.00	0.84	0.90-0.80
(27:37)	Vs	(9:7)	4	0	15.00	0.00	7.00	16.00	38.00	0.61	0.90-0.80
Plg	Vs	Pa									
(9:7)	Vs	(3:1)	1	0	89.00	0.00	17.00	38.00	144.00	4.61	0.30-0.20
(9:7)	Vs	(3:1)	2	0	102.00	0.00	25.00	54.00	181.00	4.05	0.30-0.20
(9:7)	Vs	(3:1)	3	0	39.00	0.00	16.00	21.00	76.00	0.75	0.90-0.80
(27:37)	Vs	(9:7)	4	0	15.00	0.00	7.00	16.00	38.00	0.61	0.90-0.80
Pau	Vs	Pn									
(9:7)	Vs	(3:13)	1	0	26.00	51.00	4.00	63.00	144.00	5.13	0.20-0.10
(27:37)	Vs	(3:13)	3	0	12.00	21.00	4.00	39.00	76.00	3.20	0.50-0.30
Pau	Vs	Pin									
(9:7)	Vs	(3:1)	1	0	77.00	0.00	29.00	38.00	144.00	0.46	0.95-0.90
(27:37)	Vs	(3:1)	3	0	33.00	0.00	21.00	22.00	76.00	1.12	0.80-0.70
(27:37)	Vs	(9:7)	4	0	12.00	0.00	10.00	16.00	38.00	5.10	0.20-0.10
Pau	Vs	Ps									
(9:7)	Vs	(3:1)	1	0	77.00	0.00	31.00	36.00	144.00	0.79	0.90-0.80
(27:37)	Vs	(3:1)	2	0	89.00	0.00	49.00	43.00	181.00	4.02	0.30-0.20
(27:37)	Vs	(3:1)	3	0	33.00	0.00	21.00	22.00	76.00	1.12	0.80-0.70
(27:37)	Vs	(9:7)	4	0	12.00	0.00	10.00	16.00	38.00	5.10	0.20-0.10
Pau	Vs	Pa									
(9:7)	Vs	(3:1)	1	0	77.00	0.00	29.00	38.00	144.00	0.46	0.95-0.90
(27:37)	Vs	(3:1)	3	0	33.00	0.00	22.00	21.00	76.00	0.58	0.95-0.90
(27:37)	Vs	(9:7)	4	0	12.00	0.00	10.00	16.00	38.00	7.17	0.10-0.05
Pn	Vs	Pin									
(3:13)	Vs	(3:1)	1	0	30.00	0.00	76.00	38.00	144.00	1.64	0.70-0.50
(3:13)	Vs	(3:1)	2	0	25.00	0.00	101.00	55.00	181.00	4.46	0.30-0.20
Pn	Vs	Ps									
(3:13)	Vs	(3:1)	1	0	30.00	0.00	78.00	36.00	144.00	0.44	0.95-0.90
(3:13)	Vs	(3:1)	3	0	16.00	0.00	38.00	22.00	76.00	1.22	0.80-0.70
Pn	Vs	Pa									
(3:13)	Vs	(3:1)	1	0	30.00	0.00	76.00	38.00	144.00	0.75	0.90-0.80
(3:13)	Vs	(3:1)	2	0	25.00	0.00	102.00	54.00	181.00	4.34	0.30-0.20
(3:13)	Vs	(3:1)	3	0	16.00	0.00	39.00	21.00	76.00	0.75	0.90-0.80
Pin	Vs	Ps									
(9:7)	Vs	(9:7)	4	0	22.00	0.00	0.00	16.00	38.00	0.04	0.99
Pin	Vs	Pa									
(9:7)	Vs	(9:7)	4	0	22.00	0.00	0.00	16.00	38.00	0.04	0.99
Ps	Vs	Pa									
(9:7)	Vs	(9:7)	4	0	22.00	0.00	0.00	16.00	38.00	0.04	0.99

(1995) estimated a total of 792 genes identified for various morphological characters including biochemical and resistance characters. Later, this has been extended to over 900 genes of which 209 were located in the 12 linkage groups/chromosomes (Kinoshita 1998). It may be concluded that pleitropism in rice with particular reference to anthocyanin genes is a common phenomenon. The study thus has resulted in salient findings on the phenomenon of transformation of genetic controls including pleiotropic genic relationships of morphological characters probably due to different types of chromosomal aberrations followed by random arrangements.

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