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Genetic Variability and Heritability in Bi-parental Progenies Vs Early Segregating Generations of Rice (*Oryza sativa* L.) for Important Yield Attributes

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The effectiveness of intermating or biparental mating (BIPs) was compared with conventional selfed generations (F_2 and F_3) in three intervarietal crosses *viz.,* JGL 384 × Rasi (Cross 1), KJTCMS 5B × IR 64 (Cross 2), WGL 14 × Rasi (Cross 3) of rice. The biparental progenies had better mean performance for number of productive tillers per plant and single plant yield than their F_1, F_2 and F_3 generations. The lower limit of the range was reduced for days to 50 per cent flowering, plant height in all the cross combinations and the value for 1000 grain weight was foreshortened in Cross1 and 2. More over the upper limit of certain characters particularly for number of productive tillers per plant and single plant yield was increased in the desired direction in case of intermated progenies. Although the GCV, PCV, heritability (h^2) and genetic advance were of higher magnitude in intermated progenies than in F_2 and F_3 generations for all the characters studied in all cross combinations. Intermating in early segregating generations is an effective method to generate tremendous variability in order to isolate transgressive segregants with early maturity and fine grain quality.

Key words: Biparental Progenies (BIPs), NCD II, GCV, PCV, Heritability, Genetic advance, Rice.

Rice is the most important cereal in Asia and it is cultivated in a wide range of ecosystems under varying temperature and water regimes. Success of any breeding programmes is dependent on the knowledge on the inheritance of characters of interest. But the main drawback in breeding for high yielding ability is that it is a very complex polygenic character controlled by a number of component characters being independently controlled by many genes.

To develop high yielding genotypes coupled with good grain quality and resistance to pest and diseases, population with high genetic variability serves as prime source for effective selection, particularly the role by F_2 segregants in throwing much variability is highly recognized. F_2 generations are the critical stage in any rice breeding and they determine the eventual success or failure of hybridization programme (Jennings *et al.,* 1979). Also many mating designs were proposed by many workers to know the genetics of quantitative characters. Biparental mating (BIP) is one of the simplest random mating designs available to effect forced recombination and breaking down undesirable linkages as pointed out by Comstock and Robinson (1952). The intermating in F_2 segregants provides chances of finding superior recombinants in F_3 or later generations and a great amount of concealed genetic variations particularly of additive type would be released thereby improving response to selection (Moll and Robinson, 1967). Few reports are previously available to point out the importance of variability for yield traits in rice through biparental mating. Clear understanding of the variability parameters such as Phenotypic coefficient of variation (PCV), Genotypic coefficient of variation (GCV), Heritability (h^2) and Genetic advance (GA) of the breeding material related to grain yield is much essential to know their inherent potential. Hence, the present investigation was carried out to know the effect of intermating in generating variability in comparison to F_2 and F_3 generations.

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Materials and Methods

F_2 generation seeds of three cross combinations *viz.,* JGL 384 × Rasi (Cross 1), KJTCMS 5B × IR 64 (Cross 2), WGL 14 × Rasi (Cross 3) and their corresponding five parents were raised at Paddy Breeding Station, Tamil Nadu Agricultural University, Coimbatore. F_2 generation which comprised the biparental mating block was raised in non replicated rows of 800 single plants during *Kharif* 2008-2009. In each cross combinations within F_2 population, eight plants were selected at random. Among them, four were treated as male parents and the remaining four were treated as female parents. Each male parent was crossed with each female parent. Simultaneously the respective male and female parents were also selfed to generate F_3 families. Thus sixteen biparental progenies (BIPs) were made per cross which would constitute one set as per North Carolina Design II of biparental mating (Comstock and Robinson, 1952). Like wise two sets were made per cross. A total of thirty two BIPs and sixteen F_3 families were produced per cross. For crossing wet cloth method suggested by Chaisang *et al*. (1967) was followed. Parents, F_1s, F_2, F_3 families and biparental progenies were raised during Rabi 2008-2009 in a Randomized Block Design with two replications adopting a spacing of 20 cm between rows and 10 cm between plants. F_2 populations were raised in non replicated rows. Observations were recorded on days to 50 per cent flowering, plant height, panicle length, number of productive tillers per plant, 1000 grain weight and single plant yield. The mean data collected from 98 BIPs and 48 F_3 families and F_2 generations were subjected for analysis.

Statistical analysis

According to Goulden (1952), the variance existing in F_3 progenies is considered as phenotypic variance, whereas the average of variance of the parents involved in a particular cross was taken as environmental variance (Empig *et al*., 1970). Therefore, genotypic variance is calculated by subtracting the environmental variance from phenotypic variance. Phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) were calculated by the method suggested by Burton (1952). Heritability (h^2) in the broad sense was calculated as suggested by Lush (1940) and expressed in percentage. Genetic advance and genetic advance as per cent of mean was estimated by the method formulated by Johnson *et al.* (1955).

Results and Discussion

The parents in cross 1 (JGL 384 × Rasi) showed marked differences in respect of characters like days to 50 per cent flowering, 1000 grain weight and single plant yield and the parents of cross 2 (KJTCMS 5B × IR 64) were differing for plant height and 1000 grain weight. Similarly, the parents in cross 3 (WGL 14 × Rasi) were differing for 50 per cent flowering and plant height. Mean performance of parents and their F_1 generation are presented in Table 1.

Table 1. Mean performance of parental varieties and their F_1 hybrids for various yield attributes

Parents / Hybrids	Days to 50 % flowering (Days)	Plant height (cm)	Panicle length (cm)	Number of productive tillers per plant	1000 grain weight (gm)	Single plant yield (gm)
JGL 384	104.40	80.80	21.40	11.43	18.80	25.29
KJTCMS 5B	85.40	79.60	22.00	10.40	17.21	20.86
WGL 14	99.00	84.60	22.60	12.40	19.02	22.27
IR 64	90.60	72.80	23.80	11.60	20.98	23.49
Rasi	84.60	79.20	22.200	10.80	20.71	20.84
JGL 384 x Rasi	94.20	80.00	23.20	17.40	20.25	28.98
KJTCMS 5B x IR 64	86.80	75.20	25.40	15.40	21.93	26.93
WGL 14 x Rasi	88.60	82.00	22.40	17.40	20.60	27.18

Mean performance is a basic and an important criterion in selecting superior segregants. According to Finkner *et al.* (1973), progenies with highest mean were relatively effective in selecting the superior segregants. Joshi (1979) experienced that intermating of F_2 population found to increase the population mean in BIPs. This is of immense value to the breeder, because usually population means go on decreasing progressively from F_2 generation onwards as homozygosity increases from F_3 generation onwards. In the present investigation, the mean performance of BIPs was in general, slightly better than their F_2 and F_3 progenies for almost all the characters in all three cross combinations, except days to 50 per cent flowering and plant height. In cross 1 days to 50 per cent flowering (85.53) was considerably reduced in BIPs than their parent 1 (104.40), F_1 (94.20), F_2 (86.88) and F_3 (88.29) generation. Biparental mating thus thrown additional variability for duration which would enable to select early segregating genotypes. BIPs even surpassed the mean of F_1 generation in respect to characters like number of productive tillers per plant (16.78) and single plant yield (27.90 g) in cross 2. Enhancement in the trait mean value might be due to pooling of favorable alleles through recombination which was possible because of intermating. Superior mean performance of intermated progenies appeared to be due to creation of more genetic variability by breakage of undesirable linkages which otherwise conceal the genetic variation in the small size F_2 generation. Non randomness in crossing of segregants which is unavoidable for number of productive tillers per plant due to more tillers required for crossing and selfing purposes which is directly associated with single plant yield. Enhanced mean performance of BIPs over F_2 selfs would generally be expected when major portion of the total genetic variance is additive and additive x additive type. In addition, dominance and epistatic components could play some role toward the greater mean of BIPs compared to F_2

selfs (Singh and Dwivedi, 1978). It was interesting to find that intermated or biparental progenies were early in flowering and had higher single plant yield in all cross combination indicating the chances of finding early transgressive segregants with high yielding ability.

A comparison of range values of BIPs, F_3 and F_2 generations revealed that range values was in general higher in BIPs than selfed generations. The lower limit of range was foreshortened for days to 50 per cent flowering, plant height in all cross combinations, the lower range values for 1000 grain weight was also foreshortened in cross1 and 2. More over the upperlimit of certain characters particularly for number of productive tillers per plant and single plant yield was increased in the desired direction in case of intermated progenies. It revealed that intermating in early segregating generation is an effective method to isolate transgressive segregants with early maturity and fine grain quality.

Variability in a population is measured by the estimates like phenotypic and genotypic variance, genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV). In the present study, higher genotypic variance, phenotypic variance, genotypic and phenotypic coefficient of variation of BIPs were found to be on higher side than F_2 and F_3 generations in all the cross combinations for most of the traits studied. While considering the variability in terms of genotypic coefficient of variation, BIPs showed higher variability for all the characters in cross 1 and cross 2 and all the characters except 1000 grain weight (7.77) in cross 3 when compared to F_2 (9.38) and F_3 (4.63) generation.

Table 2. Comparison of variability, heritability and genetic advance for various quantitative characters between early segregating generations (F_2, F_3) and intermated progenies (BIPs) in JGL 384 x Rasi cross combination

Characters	Generations	Mean	Range	Genotypic variance	Phenotypic variance	GCV	PCV	Heritability (h^2)	Genetic advance	Genetic advance as % of mean
Days to 50 per cent	F_2	86.88	78.00 – 100.00	20.09	23.22	5.20	5.49	86.54	8.59	9.93
flowering	F_3	88.29	81.95 – 97.21	16.91	17.45	4.66	4.73	96.88	8.33	9.44
	BIPs	85.53	73.91 – 100.09	39.98	40.36	7.39	7.43	99.05	12.97	15.16
Plant height	F_2	79.12	67.00 – 90.00	5.64	10.99	3.00	4.19	79.12	3.50	4.42
	F_3	76.56	73.60 – 80.18	3.13	7.30	2.31	3.53	42.88	2.39	3.12
	BIPs	78.69	70.78 – 85.74	19.84	20.29	5.66	5.72	97.74	9.08	11.53
Panicle length	F_2	20.76	19.00 – 23.00	0.64	0.99	3.85	4.79	64.65	1.33	6.40
	F_3	20.29	19.82 – 21.91	0.12	0.46	1.64	3.24	26.09	0.37	1.77
	BIPs	22.14	18.51 – 23.87	3.30	3.49	8.21	8.44	94.67	3.64	16.45
Number of productive	F_2	13.29	7.00 – 20.00	6.77	10.92	19.58	24.86	61.99	4.21	31.68
tillers per plant	F_3	11.46	10.34 – 13.02	0.67	0.81	7.15	7.85	82.87	1.53	13.41
	BIPs	16.39	11.46 – 22.61	11.16	11.29	20.38	20.49	98.85	6.84	41.74
1000 grain weight	F_2	19.10	17.56 – 21.44	0.83	1.03	4.77	5.34	80.83	1.68	8.79
	F_3	19.04	18.30 – 20.08	0.20	0.40	2.33	3.33	48.95	0.65	3.35
	BIPs	20.45	16.84 – 23.05	3.52	3.63	9.17	9.31	96.93	3.79	18.59
Single plant yield	F_2	23.88	17.78 – 31.11	7.66	10.10	11.58	13.33	75.87	4.96	20.77
	F_3	19.51	18.12 – 21.61	0.74	0.96	4.41	5.01	77.41	1.56	7.99
	BIPs	27.90	21.44 – 33.83	10.61	10.74	11.68	11.75	98.80	6.66	23.90

Variance in terms of phenotypic coefficient of variation, the biparental progenies showed higher variation for all the characters except number of productive tillers per plant (20.49) in cross 1; for all the characters in cross 2 and for all the characters except number of productive tillers per plant (16.34) and 1000 grain weight (7.89) in cross 3 than their F_2 and F_3 generations. It substantiated that the increase in genotypic and phenotypic variability which was not available in F_2 and F_3 generation was released in BIPs due to intermating for those traits and further it permitted more scope for selection of superior segregants in BIPs when compared to F_2 and F_3 generation.

Among the estimates of genetic parameters, heritability serves as a good index for transmission of character from one generation to next generation and it should be considered in terms of selection concept (Hanson, 1959). The heritability estimates obtained from BIPs might be more realistic than from F_3 generations, were repulsion phase of linkages tend to cause upward bias on the dominance variance (Sharma *et al.* 1979). Heritability estimates along with genetic advance are normally more helpful in predicting the gain under selection (Johnson *et al.* 1955). The estimates of variability, heritability and genetic advance for various characteristics between the intermated progenies and their corresponding F_3 and F_2 populations of three cross combinations are presented in Tables 2, 3 and 4.

Table 3. Comparison of variability, heritability and genetic advance for various quantitative characters between early segregating generations (F_2, F_3) and intermated progenies (BIPs) in KJTCMS 5B x IR 64 cross combination

Characters	Generations	Mean	Range	Genotypic variance	Phenotypic variance	GCV	PCV	Heritability (h^2)	Genetic advance	Genetic advance as % of mean
Days to 50 per cent flowering	F_2	85.27	83.00 – 95.00	7.06	8.70	3.12	3.46	81.15	4.93	5.78
	F_3	87.18	82.13 – 94.16	3.12	3.89	2.03	2.26	79.98	1.58	3.73
	BIPs	84.24	72.82 – 94.56	25.44	26.07	5.99	6.06	97.59	4.98	12.18
Plant height	F_2	77.10	75.00 – 84.00	2.73	8.70	2.14	4.35	77.10	1.91	2.48
	F_3	77.34	73.23 – 85.88	2.43	3.59	2.02	2.45	67.63	2.65	3.42
	BIPs	778.76	72.19 – 89.48	20.13	20.81	5.69	5.79	96.71	9.09	11.54
Panicle length	F_2	22.89	22.00 – 27.00	0.27	0.99	2.27	4.35	27.27	0.65	2.45
	F_3	21.98	21.01 – 25.77	0.51	0.78	3.24	4.02	64.97	.19	5.39
	BIPs	23.16	19.37 – 25.55	2.56	2.87	6.91	7.32	89.0	3.12	13.42
Number of productive tillers per plant	F_2	12.42	10.00 – 21.00	2.81	3.74	13.49	15.57	75.27	3.00	24.15
	F_3	11.73	10.23 – 13.42	0.19	0.25	3.72	4.27	75.95	0.78	6.69
	BIPs	16.78	11.43 – 22.73	7.62	7.66	16.45	16.49	99.50	5.67	33.81
1000 grain weight	F_2	20.83	20.38 – 23.55	0.40	0.64	3.03	8.96	62.50	1.03	4.94
	F_3	20.09	19.11 – 22.22	0.79	0.99	4.41	4.95	79.28	1.64	8.09
	BIPs	21.70	17.73 – 24.58	2.61	2.86	7.44	7.79	91.16	2.63	14.63
Single plant yield	F_2	23.38	20.05 – 28.99	3.47	4.39	7.96	8.96	78.93	3.40	14.23
	F_3	23.06	21.59 – 25.34	0.54	0.84	3.18	3.98	64.09	1.21	5.25
	BIPs	27.90	21.21 – 32.62	8.62	8.82	10.52	10.64	97.79	5.98	21.44

In the present investigation, a comparison of heritability estimates between BIPs, F_2 and F_3 progenies revealed that it was improved considerably in BIPs of all cross combination for all the characters. The improved heritability estimates in BIPs were probably due to higher genotypic variance recorded for yield and most of the component characters that could have resulted from additional opportunity for recombination. High heritability coupled with high genetic advance as per cent of mean was recorded by BIPs for number of productive tillers per plant in all the three cross combinations and for single plant yield in cross 1 and cross 2. This showed that gain from selection based on number of productive tillers per plant and single plant yield would be higher in biparental

Table 4. Comparison of variability, heritability and genetic advance for various quantitative characters between early segregating generations (F_2, F_3) and intermated progenies (BIPs) in WGL 14 x Rasi cross combination

Characters	Generations	Mean	Range	Genotypic variance	Phenotypic variance	GCV	PCV	Heritability (h^2)	Genetic advance	Genetic advance as % of mean
Days to 50 per cent flowering	F_2	88.60	82.00 – 99.00	12.14	13.24	3.93	4.10	91.69	6.87	7.75
	F_3	89.85	84.50 – 97.00	13.99	115.25	4.16	4.35	91.79	7.37	8.23
	BIPs	83.64	74.61 – 94.33	32.35	32.90	6.79	6.86	98.31	11.61	13.89
Plant height	F_2	83.86	81.00 – 91.00	3.50	6.56	2.23	3.05	53.35	2.82	3.36
	F_3	77.80	74.14 – 83.59	6.92	7.69	3.38	3.57	89.96	5.15	6.61
	BIPs	79.52	71.64 – 87.95	26.41	26.78	6.46	6.51	98.64	10.52	13.22
Panicle length	F_2	21.98	20.00 – 25.00	0.77	1.17	3.99	4.92	65.81	1.47	6.69
	F_3	20.97	19.51 – 21.79	0.44	0.51	3.16	3.39	86.67	1.28	6.06
	BIPs	21.48	18.16 – 24.32	3.89	3.54	8.69	8.76	98.37	4.26	17.76
Number of productive tillers per plant	F_2	12.98	9.00 – 20.00	4.08	4.98	15.56	17.19	81.96	3.76	28.96
	F_3	11.86	10.54 – 12.46	0.24	0.36	4.14	5.03	67.63	0.83	7.01
	BIPs	16.81	11.62 – 22.28	7.51	7.54	16.29	16.34	99.53	5.58	33.49
1000 grain weight	F_2	19.71	17.44 – 21.88	3.42	5.58	9.38	9.84	60.88	2.99	15.16
	F_3	18.16	16.08 – 20.10	0.71	0.78	4.63	4.86	90.87	1.66	9.09
	BIPs	21.12	17.91 – 23.84	2.69	2.78	7.77	7.89	96.81	3.32	15.74
Single plant yield	F_2	24.01	19.39 – 31.37	3.41	5.58	7.68	9.87	60.088	2.98	12.41
	F_3	21.88	20.59 – 23.19	0.99	1.44	4.55	5.49	68.77	1.70	7.78
	BIPs	27.82	23.24 – 33.56	7.04	7.11	9.54	9.58	98.98	5.43	19.54

progenies. These results were in accordance with the findings of Palanisamy (1980), Shanthi (1989) and Yuvaraja (2000) in rice.

High heritability coupled with high genetic advance indicated that most likely the heritability is due to additive genetic effects and the selection may be effective. Johnson *et al.* (1955) and Gurdev singh *et al.* (1986) reported that generally yield and its component characters depict low heritability, but in case of BIPs the heritability was higher than F_2 and F_3. It suggested that environment played relatively limited role in influencing the inheritance of these characters and thus the response to selection would be higher in intermated progenies. High heritability coupled with moderate genetic advance was recorded by intermated progenies for the characters like days to 50 per cent flowering, plant height, panicle length and 1000 grain weight in cross 1 and cross 2 and all the characters in cross 3 except number of productive tillers per plant.

As is expected on genetic principles, the usefulness of intermating is largely dependent on the aspects like genetic architecture and the nature of linkages among the genes controlling specific traits. Utility of intermating would, therefore, be pronounced if the additive or additive × additive types of genetic variances are predominant coupled with repulsion phase linkages between the genes. Nevertheless, this approach will help in creating new populations with high frequencies of rarer recombinants which can not be realized in small segregating populations normally being raised through the conventional methods of breeding especially when the desired genes are unfavorably linked. Intermating in early segregating generations will also help in maintaining a greater genetic variability for selection to be carried out for longer period and will thus avoid early fixation of genes in homozygous state.

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