Proc Indian natn. Sci. Acad. B47 No. 5 pp 700–707 (1981)

Genetic Analysis of G × E Interaction in Derivatives of *Ponni* × IR. 20 Rice in Summer and Monsoon Seasons

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(Received 15 December 1980; after revision 3 October 1981)

Twenty-nine hybrid derivatives of *Ponni* × IR.20 rice were studied in advance generations during summer and monsoon seasons of 1977–78 at Pondicherry conditions. G × E interactions were significant for panicle length, grain number per panicle, grain yield per plant and plot. The PCV, GCV, h^2_B and GA estimates were high for grain yield per plant in both seasons. Other characters showed differential expressions across the seasons. The correlation, regression and path analysis indicated the greater influence of grain yield per plant on grain yield per plot than other characters.
A simple technique of standardised mean graph was attempted to group the hybrid derivatives for their stability over seasons and the practical utility was discussed.

Keywords: Genetic interaction, *Ponni*, IR. 20, Seasonal variation

Introduction

Mahsuri (*Ponni*) variety of rice is of 130–135 days duration and is being largely grown in monsoon season in Tamil Nadu and Pondicherry. In a programme to improve *Ponni* for its high yielding potentialities this variety was hybridised with IR.20 and the segregants were bred through F_2 to F_6 and finally 29 lines were advanced. These hybrid derivatives were tested for their performance in two seasons viz., summer (1977–78) and monsoon (1977–78) under Pondicherry conditions. The magnitude of variation, their differential interaction to seasons, interrelation between grain yield and yield attributes, were assessed.

Material and Methods

Twenty-nine lines of *Ponni* × IR.20 were evaluated in summer and monsoon (1977–78) seasons at *Krishi Vigyan Kendra*, Pondicherry. *Ponni* and IR.20 were included as parental checks. The field experiment was laid out in a randomised block design replicated twice with a spacing of 20 × 10 cm. The plot size was 4 M × 3 M. During monsoon (September 1977–January 1978) and summer (Jan. '78 —May '78), six characters namely, plant height (cm), number of productive tillers, length of panicle (cm), number of grains per panicle, grain yield per plant (g) and grain yield per plot (kg) were recorded. Phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability estimate in broad sense (h^2_B) and genetic advance as percentage of mean were estimated and expressed in per cent (Burton 1952, Johnson et al. 1955). The estimates of simple correlation coefficients and partial regression coefficients were worked out and the multiple linear regression equation was also fitted (Goulden 1952). The genotypic correlation coefficients were used for partitioning into direct and indirect effects through the path analysis (Dewey & Lu 1959). The standardised mean for individual cultivars was calculated for monsoon and summer seasons separately using the formula:

Xi—mSd where, Xi=grain yield of individual lines; m=mean of all cultures pooled together; and Sd=standard deviation.

The standardised means of individual cultures for monsoon and summer seasons were plotted in a standardised regression graph with monsoon and summer seasons in X and Y axis respectively. A dotted ideal regression line was drawn through the origin with unit slope. This graph measures the relative stability of cultures over summer and monsoon seasons. The genotypes which were located near the ideal regression line denote the stable and consistence performance of the material over seasons and the ones away from the regression slope indicate the differential reactions to seasons. This graph allows us to cluster the cultures into four groups, according to the quadrants in the graph in which the cultures were located.

+ + (1st quadrant) = ideally suited to both seasons

+— (2nd quadrant) = suited to monsoon season

—+ (3rd quadrant) = suited to summer season

—— (4th quadrant) = low yielders in both seasons

Results and discussion

Analysis of variance (table 1): The hybrid derivatives differed among themselves significantly in individual environments as well in combined analysis for plant height, number of grains per panicle and grain yield per plot. For other characters there was lack of statistical significance between the genotypes in one or both environments or in combined analysis. The mean squares due to G×E interaction were significant for length of panicle, number of grains per panicle, grain yield per plant and grain yield per plot indicating that genotypes reacted differently in summer and monsoon seasons for these characters. The variance due to season was also significant for all characters except for length of panicle and thereby indicating differential phenotypic expression of characters in summer and monsoon seasons.

Phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), broad sense heritability (h^{2}_{B}), and genetic advance as percentage of mean (GA) (table 2): The PCV and GCV were highest for grain yield per plant under both environmental situations among characters. Similarly, the h^2_B and GA were also highest for this trait. Therefore, further selections are possible among the genotypes. Grain yield per plot and number of grains per panicle also had high PCV, GCV, h^2_B and GA but differential expression among seasons was observed. Other traits had low estimates of these parameters and hence further yield improvement through selection of these characters may not be possible using the materials under study.

The mean performance of the individual hybrid derivatives was compared with the parents. It was found that the mean values differed over the seasons and the mean performance in summer season was more favourable than the monsoon for the phenotypic expression of characters as indicated by the general mean of all characters except for number of grains per panicle. Length

Table 1 *Analysis of variance for six characters*

Source	D. F.	Mean squares for					
		Plant height	Tiller number	Panicle length	Number of grains per panicle	Grain yield per plant	Grain yield per plot
			Monsoon season				
Types	30	218.39**	1.17	2.61*	432.18**	30.52**	0.83**
Error	30	42.85	1.27	1.37	98.39	8.25	0.19
			Summer season				
Types	30	241.90**	2.10	3.39	947.94**	349.59**	0.50
Error	30	35.85	1.30	2.09	218.03	33.60	0.26
			Pooled analysis				
Season	1	25894.40**	109.27**	1.81	33749.10**	52851.61**	139.60**
Types	30	407.47**	1.77	2.99	880.85**	196.32	0.95**
Season × Types	30	52.82	1.50	3.01*	499.27**	183.79**	0.39*
Error	60	39.35	1.29	1.73	158.21	20.93	0.22

* Significantat 5% level, ** Significant at 1% level

Table 2 *Phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability estimates in broad sense (h^2_B) and genetic advance as % of mean (GA) for different characters*

Characters		PCV (%)	GCV (%)	h^2_B(%)	GA	PCV—GCV
Plant height	M	10.17	9.12	85.18	16.86	1.05
	S	8.35	7.71	80.38	14.67	0.64
Tiller number	M	15.28	—	—	2.40	—
	S	14.62	9.02	38.05	11.48	5.60
Panicle length	M	5.05	3.48	47.48	4.95	1.37
	S	5.82	3.60	38.26	4.59	2.22
Number of grains per panicle	M	9.63	8.46	77.23	15.33	1.17
	S	18.19	15.96	77.00	28.89	2.23
Grain yield per plant	M	24.27	20.73	72.96	36.51	3.54
	S	23.04	21.90	90.39	42.94	1.14
Grain yield per plot	M	23.46	20.54	76.66	37.08	2.92
	S	10.25	7.09	47.91	10.13	3.16

M=Monsoon season, S=Summer season

of panicle, however, did not show difference in both the seasons in mean values. The genotypes had higher number of grains per panicle during monsoon than in summer. However, this was not reflected in terms of grain yield. Probably, monsoon season may not had the proper environment for supporting or sustaining biological factors for necessary tiller development and filling of grains and thereby had poor grain yields.

The standardised mean graph for clustering the hybrid derivatives into groups is presented in figure 1.

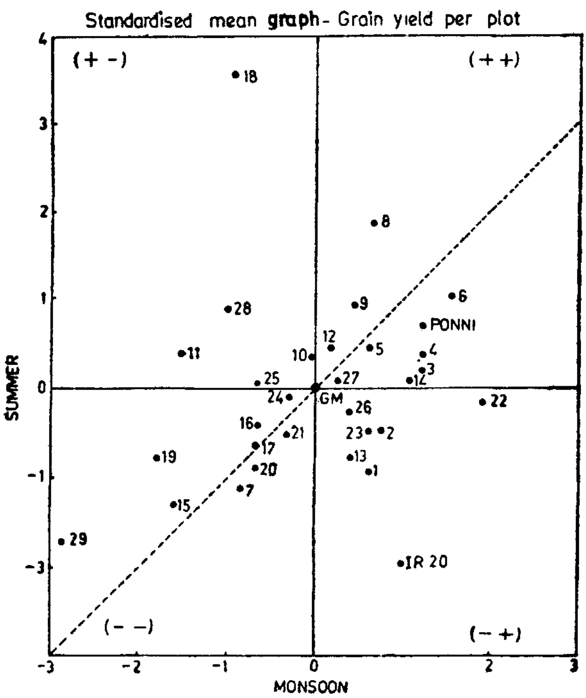

Figure 1 Standardised mean graph

1, 157/1; *2*, 159/2; *3*, 160/2; *4*, 161/1; *5*, 162/2; *6*, 162/3; *7*, 163/2; *8*, 166/3; *9*, 167/1; *10*, 172/1; *11*, 172/3; *12*, 174/1; *13*, 174/3; *14*, 175/3; *15*, 177/1; *16*, 173/3; *17*, 179/1; *18*, 179/2; *19*, 179/3; *20*, 180/3; *21*, 184/2; *22*, 184/3 *23*, 185/3; *24*, 189/3; *25*, 190/1; *26*, 191/3; *27*, 192/2; *28*, 194/3; *29*, C. 4407; *30*, IR 20; and *31*, *Ponni*.

The hybrid derivatives 162/3, 166/3, 167/1, 174/1, 162/2, 192/2, 161/1, 160/2, 175/3 and *Ponni* lie in + + quadrant of the graph indicating that these lines are high yielding and stable in performance in monsoon and summer seasons. Among these cultivars, 162/3 showed substantial superiority over *Ponni* in both environmental situations. On the contrary, the derivatives 179/2, 194/3, 172/3, 172/1 and 190/1 were plotted in +— quadrant and therefore suitable for summer environment alone. The culture 179/2 had maximum yield among these derivatives. The cultures 191/3, 185/3, 192/2, 174/3, 157/1, and 184/3 including the parent IR.20 were located in —+ quadrant and hence ideally suited for monsoon season. The culture 184/3 was found to be the best for monsoon season. Nine genotypes located in the — — quadrant were low yielding in both seasons.

Phenotypic correlation coefficients and partial regression coefficients (table 3) : Grain yield per plant alone showed significant and positive correlation with grain yield per plot in both the seasons. Plant height exhibited positive associations in both seasons. However, it was significant in summer season only. In four pairs of inter-character associations significance was expressed in summer season, while it was not so in monsoon season. Thus the influence of environment on the expression of character association was brought out in the present study.

The partial regression coefficient of plant height and grain yield per plant was positive and significant on grain yield per plot in both seasons while that of number of grains per panicle was negative and significant in monsoon season only. All other characters had negative non-significant or non-significant contributions towards grain yield per plot. However, R^2 values were very low in both seasons indicating that only 20% and 21% of variation in grain yield per plot could b

Table 3 *Phenotypic correlation coefficient and partial regression coefficients in summer (S) and monsoon (M) seasons*

Character		Tiller number (X_2)	Panicle length (X_3)	No. of grains per panicle (X_4)	Grain yield per plant (X_5)	Grain yield per plot	Partial regression coefficients
Plant height (X_1)	S	0.0911	—0.1222	—0.4133**	0.0108	0.2864*	0.0189* ± 0.0086
	M	—0.1865	0.1299	0.1337	0.0035	0.2108	0.0173* ± 0.0077
Tiller number (X_2)	S		0.1671	—0.0830	—0.3272**	−0.1712	—0.0433 ± 0.0716
	M		—0.0834	0.1022	0.2214	0.0506	0.0338 ± 0.0810
Panicle length (X_3)	S			0.5661**	0.1550	—0.0951	0.0547 ± 0.0691
	M			—0.0348	—0.0245	—0.1408	—0.0888 ± 0.0609
No. of grains per panicle (X_4)	S				0.3070*	—0.0429	0.0016 ± 0.0051
	M				0.0718	—0.1916	—0.0114* ± 0.0053
Grain yield per plant (X_5)	S					0.3144*	0.0150* ± 0.0070
	M					0.2787*	0.0456* ± 0.0198

R^2 S=0.1984 M=0.2137

$\hat{y}$ (Summer) $= 2.8560 + 0.0189^* X_1 - 0.0433 X_2 - 0.0547 X_3 + 0.0016^* X_4 + 0.0456^* X_5$

$\hat{y}$ (Monsoon) $= 3.8145 + 0.0173^* X_1 + 0.0338 X_2 - 0.0883 X_3 - 0.0114^* X_4 + 0.0456^* X_5$

Table 4a *Path analysis showing the direct and indirect effects of five characters on grain yield in Ponni × IR. 20 derivatives (Summer)*

Characters	Plant height	Number of tillers	Length of panicle	Number of grains/panicle	Grain yield per plant	γ_g with grain yield/plant
Plant height	*0.1241*	0.0461	0.0629	0.3168	0.0400	0.4641
Number of tillers	—0.0437	*—0.1308*	0.1773	—0.0519	—0.2722	—0.3213
Length of panicle	—0.0351	—0.1042	*—0.2226*	—0.5037	0.2143	—0.2061
Number of grains/panicle	0.0664	—0.0114	0.1893	*—0.5922*	0.1633	—0.3174
Grain yield per plant	0.0124	0.0893	0.1195	—0.2423	*—0.3991*	0.3780

Figures in italics show direct effect
(Residual effect p_x=0.7794)

Table 4b *Path analysis showing the direct and indirect effects of four characters on grain yield in Ponni × IR. 20 derivatives (Monsoon)*

Characters	Plant height	Length of panicle	Number of grains/panicle	Grain yield per plant	γ_g with grain yield/plant
Plant height	*0.3737*	—0.0094	—0.0689	—0.0148	0.2806
Length of panicle	0.0191	*—0.1829*	0.0039	—0.1412	—0.3011
Number of grains/panicle	0.0860	0.0024	*0.2993*	0.0853	—0.1257
Grain yield per plant	—0.0115	0.0538	—0.0531	*0 4803*	0.4694

Figures in italics indicate direct effects
(Residual effects (p_x)=0.7596)

explained by the independent variables in summer and monsoon seasons respectively.

Path analysis for summer and monsoon seasons (tables 4a & 4b): In summer, number of grains per panicle exerted the highest direct effect followed by grain yield per plant and panicle length. Number of grains per panicle exerted positive indirect effects via grain yield per plant on grain yield per plot. In monsoon season, grain yield per plant, followed by plant height showed positive and high direct effect on grain yield. Other two characters showed negative direct effects on grain yield.

Thus the number of grain and grain yield per plant showed the highest direct effect in summers eason whereas in the monsoon season grain yield per plant exerted highest direct effect on grain yield per plot. The investigation has shown that G × E interaction component for yield and its attributes was found to be highly significant revealing that the genotypes or derivatives behaved differently in different seasons at the same location. The mean performance of the genotypes and their ranking also differed in the two different seasons besides different trends in path analysis, indicating the need for separate evaluation programmes for the different seasons.

Acknowledgements

The authors are much thankful to Dr R Rathnasamy, Associate Professor (Genetics) for his assistance and help in preparing the paper.

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