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SELECTION OF PARENTS AND PREDICTION OF HETEROSIS IN RICE

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ABSTRACT

An experiment was conducted to study the relationships between parental lines and heterosis by using 29 hybrids, 26 restorers and 3 maintainers. The results revealed that the reproductive phase initiation(RI) was invariably early in hybrids. The reproductive phase duration (RD) was invariably longer in hybrids which showed better parent heterosis. The distribution of parents based on DMRT followed by joint scoring over seven traits indicated most parents in Medium group which contained 87% of the promising restores (whose hybrid combinations showed better parent heterosis for yield). The relationship between parental lines showed that heterosis resulted from the complementation of traits. A thorough evaluation of restorers for various traits is necessary to choose appropriate ones and the restorers for making heterotic combinations should be drawn preferably from Medium group.

Key words : Rice, heterosis, prediction, selection of parents

The magnitude of heterosis primarily depends on the choice of appropriate parental lines. To increase the efficiency of heterosis breeding, there is a need to identify simple and dependable criterion to select parental lines which would result in heterotic combinations without necessarily making all possible crosses among the potential parents and evaluating them. Several methods (*per se* performance, combining ability and genetic diversity, etc.) have been used to choose parents *a priori* with varying success [1]. Studies on combining ability in relation to heterosis have been reviewed [2-3]. The results of such studies have not been much useful in choosing parents for yield heterosis, because yield is a complex trait determined by many components which in turn are governed by different sets of gene(s) [4] and there is hardly any study to show that combining ability effects of certain traits are useful in predicting yield heterosis. Similarly, the genetic diversity studies using D^2 statistic of Mahalanobis [5] have been in use for selection of prospective parents of the hybrids. The results obtained from such studies have not been consistent in clearly

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demonstrating the relationships between the divergence of parental lines and magnitude of heterosis [6-10], because they are influenced by type of material, selection of traits, etc. Often, the traits that contribute more to divergence have very little to do with a complex trait such as yield. Therefore, an attempt was made to identify and establish simple relationships between the traits of parental lines and the magnitude of heterosis in their hybrids to facilitate choice of appropriate parental lines for obtaining heterotic combinations.

MATERIALS AND METHODS

During wet season 1995, in International Hybrid Rice Observational Nursery (IRHON), 29 hybrids, 26 restorers and 3 maintainers were evaluated in an augmented design. In each of the hybrids and their respective restorers, 3-5 plants were dissected to identify the initiation of reproductive phase (RI) marked by the formation of a hairy like structure. At maturity, grain yield/m^2 and observations on several yield traits in five randomly selected plants were recorded. Besides, the number of days to 50% flowering (DFF) was also recorded. The data collected on seven traits viz., plant height (HT), number of panicles/plant (PN), panicle weight (PW), number of fertile spikelets (FS), spikelet fertility per cent (SFP), 100 grain weight (TW) and grain yield (GY) were used to classify the parents (restorers and maintainers). Initially, overlapping groups of parents were obtained for each trait based on DMRT. Then, a joint score over 7 traits was computed for each line/parent following a method as detailed by Arunachalam and Bandyopadhyay [11]. Using mean and standard deviation of joint scores, three groups : High, Medium and Low were made. The percentage of promising restorers (whose hybrid combinations showed better parent heterosis) was calculated for each group.

RESULTS AND DISCUSSION

The relationship between reproductive phase duration (RD) and heterosis is presented in Figure 1. Heterosis was calculated over better parent. In our study, mostly the restorer was found to be a better parent compared to maintainer (the counterpart of the female parent). It is clear from the figure that in hybrids with better parent heterosis, (H > R), the RD i.e., the period from reproductive phase initiation to 50% flowering (RI to DFF) was longer compared to the better parent, but with no change in growth duration. While, in hybrids where grain yield was less than their restorers (H < R) there was no difference in RD, but the growth duration was shorter compared to restorers. Variation ranging from 27-46 days for RD has been observed in conventional varieties. But, there are no reports in rice indicating the relationship between heterosis and period of RI. However, physiological

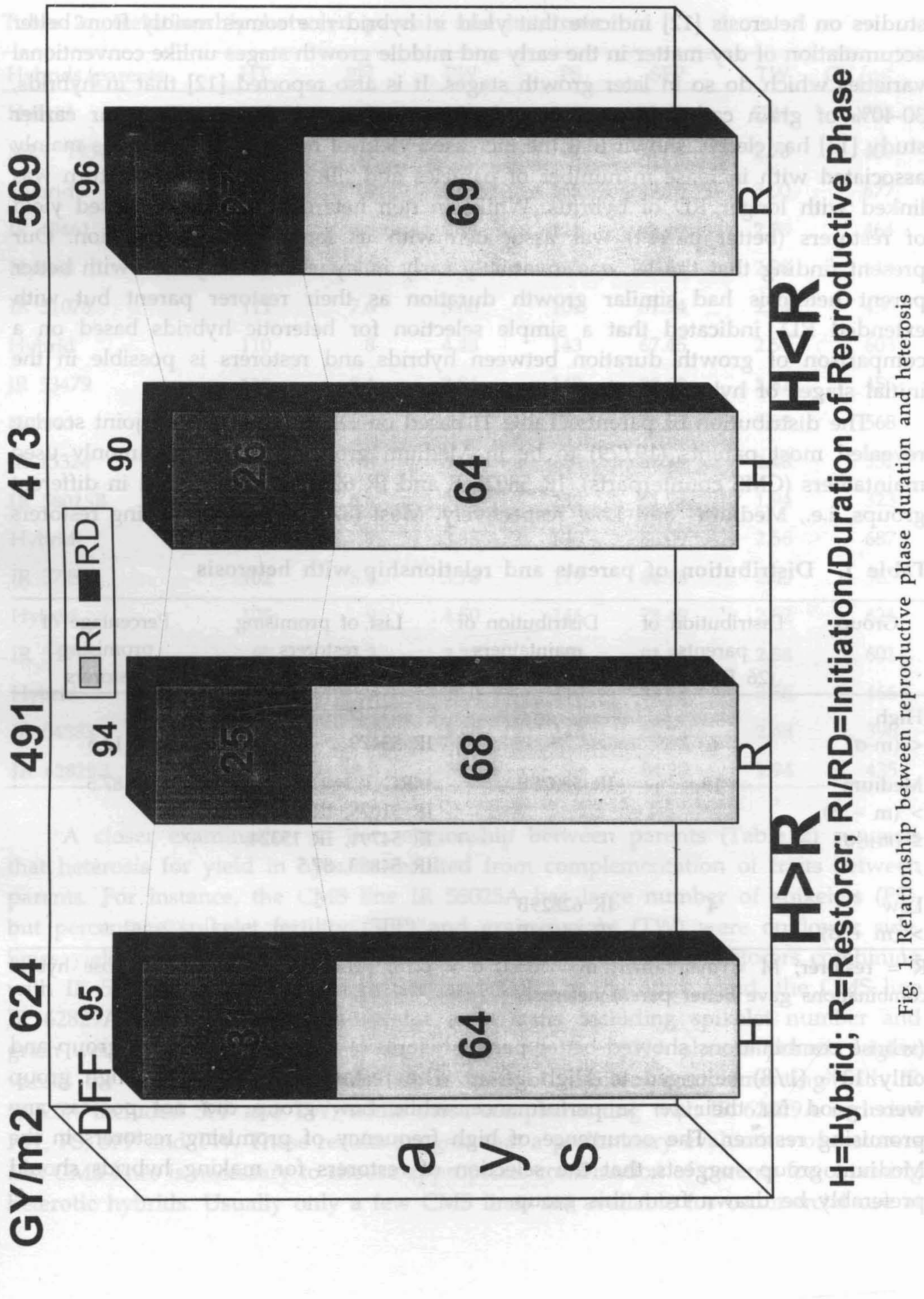

Fig. 1. Relationship between reproductive phase duration and heterosis

studies on heterosis [12] indicate that yield in hybrid rice comes mainly from better accumulation of dry matter in the early and middle growth stages unlike conventional varieties which do so in later growth stages. It is also reported [12] that in hybrids, 30-40% of grain carbohydrates come from assimilation before heading.Our earlier study [13] has clearly shown that the increased yield of heterotic hybrids was mainly associated with increase in number of panicles and filled grains which in turn was linked with longer RD of hybrids. While, in non heterotic .hybrids increased yield of restorers (better parent) was associated with its longer growth duration. Our present finding that the RI was invariably early in hybrids and hybrids with better parent heterosis had similar growth duration as their restorer parent but with extended RD, indicated that a simple selection for heterotic hybrids based on a comparison of growth duration between hybrids and restorers is possible in the initial stages of hybrid development.

The distribution of parents (Table 1) based on DMRT followed by joint scoring revealed most parents (19/29) to be in Medium group. The two commonly used maintainers (CMS counterparts), IR 58025 B and IR 62829 B were found in different groups, i.e., Medium and Low respectively. Most (87%) of the promising restorers

Table 1. Distribution of parents and relationship with heterosis

Group	Distribution of parents (26 R + 3M)	Distribution of maintainers	List of promising restorers	Percentage of promising restorers
High < (m-σ)	6	-	IR 53479	12.5
Medium > (m − σ) ≤ ($m+\sigma$)	19	IR 58025B	MRC 19340, IR 49461, IR 51078, IR 57298, IR 54791, IR 15324, IR 54883, 87.5	87.5
Low > (m + σ)	4	IR 62829B IR 64608B	-	-

R = restorer; M = maintainer; m = 0.54; σ = 0.15; Promising restorers = whose hybrid combinations gave better parent heterosis.

(whose combinations showed better parent heterosis) were from Medium group and only 13% (1/8) belonged to High group. The restorers belonging to High group were good for their *per se* performance, while Low group did not possess any promising restorer. The occurrence of high frequency of promising restorers in the Medium group suggests that the selection of restorers for making hybrids should preferably be drawn from this group.

Table 2. Relationship between parents and heterosis

Hybrids/parents	HT	PN	PW	FS	SFP	TW	GY/m^2
Hybrid	118	8	4.38	160	93.02	2.84	758
MRC 19340	**103**	7.2	3.14	92	**89.03**	**2.70**	480
Hybrid	111	10	2.64	165	89.20	3.00	677
IR 49461	**111**	6.8	2.96	111	**88.40**	**2.78**	464
Hybrid	109	10	3.52	97	67.65	2.98	614
IR 51078	**111**	7.6	3.60	108	81.94	**2.74**	430
Hybrid	110	8	4.48	143	67.45	2.56	603
IR 53479	**113**	8.4	3.84	142	**88.60**	**2.82**	456
Hybrid	107	9	4.40	159	85.95	3.02	568
IR 15324	**103**	8	3.66	104	**87.39**	**2.48**	532
IR 58025B	98	**8.6**	**3.48**	**132**	81.96	1.94	323
Hybrid	106	9	3.58	130	86.09	2.56	687
IR 57298	**102**	8.4	**3.78**	119	**84.98**	**2.60**	565
Hybrid	105	9	4.50	146	78.49	2.52	621
IR 54791	**97**	8.2	**3.32**	**109**	**91.56**	**2.58**	601
Hybrid	87	9	3.62	110	81.48	2.56	466
IR 54883	**98**	9	**3.48**	**118**	**86.72**	**2.48**	396
IR 62829B	82	**9.8**	3.16	99	84.20	1.94	435

A closer examination of the relationship between parents (Table 2) suggests that heterosis for yield in hybrids resulted from complementation of traits between parents. For instance, the CMS line IR 58025A has large number of spikelets (FS), but percentage spikelet fertility (SFP) and grain weight (TW) were on lower side. Since yield is a function of grain number and grain weight, the restorers combining with IR 58025A should have high SFP and TW. On the other hand, the CMS line IR 62829A possesses lower values for most traits including spikelet number and grain weight. Therefore, restorers combining with IR 62829A should possess higher values for many traits. Thus, the set of traits of restorers complementing with IR 58025A included SFP and TW, while those complementing with IR 62829A included PW, FS, SFP and TW. These results suggest that a preliminary evaluation of restorers and CMS lines is necessary to choose appropriate combination of parents for obtaining heterotic hybrids. Usually only a few CMS lines are available for commercial use at a time and therefore, a thorough evaluation of restorers for various traits would help in choosing appropriate ones for obtaining heterotic combinations.

REFERENCES

1. S. S. Virmani. 1996. Hybrid Rice. Advances in Agron., **57**: 377-462.
2. C. H. Kim and J. N. Rutger. 1988. Heterosis in Rice. *In*: Hybrid Rice, pp. 39-54. Int. Rice. Res. Inst., Manila, Philippines.
3. S. S. Virmani. 1994. Heterosis and hybrid rice breeding. Springer Verlog, Berlin.
4. J. E. Grafius. 1959. Heterosis in barley. Agron. J., **51**: 551-554.
5. P. C. Mahalanobis. 1936. On the generalized distance in statistics. Proc. Natl. Inst. Sci., India. B **2**: 49-55.
6. A. W. Julfiquar, S. S. Virmani and A. L. Carpena. 1985. Genetic divergence among some maintainer and restorer lines in relation to hybrid breeding in rice (*Oryza sativa* L.). Theor. Appl. Genet., **70**: 671-678.
7. C. Li and S. Ang. 1988. Genetic distance and heterosis in *japonica* rice. *In*: Hybrid Rice, p. 257. Int. Rice Res. Inst., Manila, Philippines.
8. J. Y. Peng, S. S. Virmani and A. W. Julfiquar. 1991. Relationship between heterosis and genetic divergence in rice. Oryza., **28**: 129-133.
9. S. S. Virmani, J. B. Young, H. P. Moon, I. Kumar and J. C. Flinn. 1991. Increasing rice yields through exploitation of heterosis. IRRI Research Paper Series Number 156. Int. Rice Res.Inst, Manila, Philippines.
10. S. S. Virmani, G. S. Khush and P. L. Pingali. 1994. Hybrid rice for tropics : Potential research priorities and policy issues. *In*: Hybrid Research and Development of Major Cereals in Asia Pacific Region (Eds. R.S. Paroda and M. Rai), pp. 61-86. FAO, Bangkok.
11. V. Arunachalam and A. Bandyopadhyay. 1984. A method to make decisions jointly on a number of dependent characters. Indian J. Genet., **44**(3): 419-424.
12. Yan Zhende. 1988. Agronomic management of rice hybrids compared with conventional varieties. Hybrid Rice, pp. 217-223. Int. Rice Res. Inst., Manila, Philippines.
13. C. H. M. Vijayakumar, M. Ilyas Ahmed, B. C. Viraktamath and M. S. Ramesha 1997. Heterosis : early predication and relationship with reproductive phase. IRRN., **22**(2): 8-9.