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STUDIES ON HETEROSIS FOR YIELD AND YIELD RELATED TRAITS IN RICE (*ORYZA SATIVA* L.)

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ABSTRACT

An investigation in rice was undertaken to study the nature and magnitude of heterosis for yield and yield component traits involving seven lines, three testers and twenty one hybrids were developed through line × tester mating design. Observations were recorded for days to 50 per cent flowering, plant height, number of productive tillers per plant, panicle length, number of grains per panicle, 100 grain weight and grain yield per plant. Significant heterosis for grain yield and yield component traits were observed in most of the hybrids. Twenty one hybrids and eighteen crosses out of twenty one hybrids exhibited significant and positive heterobeltiosis and standard heterosis for grain yield per plant, respectively. Heterobeltiosis ranging from 10.13 to 40.63 per cent and standard heterosis from 5.95 to 44.23 per cent for grain yield per plant were observed. The most promising specific combination identified for grain yield per plant were (STBN 16 × ADT 46) and also recorded significant and positive standard heterosis for all the yield component traits studied.

Key words : Standard heterosis, Heterobeltiosis, Line × Tester.

Introduction

Rice (*Oryza sativa* L. 2n = 24) belongs to the family Poaceae. It occupies an important role in Indian agriculture. The United Nation designated, year 2004 as the "International Year of rice". Rice is primarily composed of carbohydrates, contains almost no cholesterol. The nutrient composition of rice includes 6.8 per cent protein, 78.20 per cent carbohydrate, 0.3 per cent fat and 0.6 per cent minerals. India is one of the major rice producing and consuming countries in the world. It is the second largest producer in the world after China. Rice is grown throughout the world in 159.46 million hectares with the production of 472.52 million tones. In India, rice occupies an area of about 43.50 million hectares with the production of 104.41 million tones as per USDA (2015-2016). As the world's population continues to increase, there will be further demand on rice supply to meet additional consumption requirement. Improvement in the area under cultivation is highly impossible but the productivity could be improved through genetic manipulation.

Hybrid rice technology is a feasible and economically sound approach for yield enhancement in rice. The success of heterosis breeding programme largely depends on the efficiency of choosing appropriate parents of good genetic potential. The parents should possess wide genetic diversity and good combining ability for various economic traits. Many biometric tools are made available to the breeder for selecting the desirable parents. Line × tester analysis introduced by Kempthorne (1957) is one of the powerful tool available to estimate the combining ability effects and helps in selecting desirable parents and crosses.

Materials and Methods

The experimental material comprised of 10 genotypes. The seven genotypes STBN 21, STBN 11, STBN 16, STBN 13, STBN 10, STBN 12, STBN 7 were used as lines (female) and the remaining three genotypes IR 20, ADT 46, White Ponni were used as testers (male). The parents were crossed at the flowering time to produce 21 F_1 hybrids according to line × tester mating design.

Twenty five days old seedlings were transplanted at the rate of three seedling/ hill. Each genotype was grown as a single row of 10 plants following 15×20 cm plant to plant and row to row spacing. Recommended agronomic practices were adopted. All the parents and crosses were raised in randomized complete block design with three replications at the Department of Genetics and Plant breeding, Annamalai University, Chidambaram during two seasons January to April 2017 and July to October 2017.

The observations were recorded on ten yield and yield-related traits viz; days to 50 per cent flowering, plant height (cm), no of productive tillers per plant, panicle length(cm), no of grains per panicle, hundred grain weight(g) and grain yield per plant(g) from five randomly selected plants/replication.

Heterosis

The mean of parents and F_1 hybrids were utilized for the estimation of heterosis. The heterobeltiosis (d_{ii}) and standard heterosis (d_{iii}) were estimated as follows:

$$\text{Heterobeltiosis } (d_{ii}) = \frac{F_1 - BP}{BP} \times 100$$

$$\text{Standard heterosis } (d_{iii}) = \frac{F_1 - SV}{SV} \times 100$$

Where,

F_1 = mean of the F_1- hybrid

BP = mean of the better parent

SV = mean of the standard variety

In the present study, ADT 46 was considered as the standard parent.

Test of significance of heterosis

The significance of heterosis was tested using the formula as suggested by Wynne *et al*. (1970).

i. 't' over Heterobeltiosis (d_{ii})

$$= \frac{\overline{F_1} - \overline{BP}}{\left(2\sigma_e^2/r\right)^{1/2}}$$

ii. 't' over standard heterosis (d_{iii})

$$= \frac{\overline{F_1} - \overline{SV}}{\left(2\sigma_e^2/r\right)^{1/2}}$$

Where,

'σ_e^2' is the error variance obtained from the analysis of variance.

'r' is the number of replications. The calculated 't' value was compared with the table of 't' at the error degrees of freedom.

Results and Discussion

The value of heterosis for hybrids were estimated based on better parent (d_{ii}) and standard parent performance (d_{iii}) (Table 1). Negative heterosis for days to 50 per cent flowering is desirable for breeding early maturing hybrids and varieties. In this trait most of the hybrids exhibited negative significant values in heterobeltiosis. The maximum significant and negative value for standard heterosis was recorded in the cross STBN 11/White Ponni (-12.75 per cent) followed by STBN 16/White Ponni (-9.80 per cent). All the twenty one hybrids recorded negative significant values ranged from -2.38 to -12.75 per cent for days to 50 per cent flowering. Early flowering in hybrids had been reported by Nadali Bagheri (2010) and Premkumar *et al*. (2017).

Negative heterosis for plant height is desirable for breeding short statured hybrids and varieties to withstand lodging. For heterobeltiosis, values ranged from -4.61 to -31.68 per cent. The maximum significant and negative value was recorded by the cross STBN 11/White Ponni (-31.68 per cent). Eighteen hybrids recorded negative significant standard heterosis which ranged from -4.61 to -29.00 per cent. The cross STBN 16/ADT 46 (-29.00 per cent) recorded the highest significant and negative d_{iii} value for this trait. Short statured hybrid was also reported by Patil *et al*. (2012) and Bineeta Devi (2017).

More productive tillers per plant is believed to be associated with high grain yield per plant and so the hybrids with high productive tillers per plant were selected. For heterobeltiosis, the maximum significant and positive value was recorded by the cross STBN 16/ADT 46 (16.59 per cent). Seven and four hybrids recorded positive significant heterosis over better and standard parent whose value ranged from 3.99 to 16.59 per cent. The cross STBN 16/ADT 46 (16.59 per cent) recorded the highest significant and positive d_{iii} value for this trait.

For panicle length, the hybrids with positive heterosis are desirable. The cross STBN 16/ADT 46 produced the maximum significant and positive d_{ii} and d_{iii} values (11.09 per cent). Eight and four hybrids recorded positive significant value over better and standard parent for this trait.

Number of grains per panicle is an important component attributing towards grain yield per plant. Among the hybrids, STBN 21/ADT 46 and STBN 16/ ADT 46 registered the maximum significant and positive d_{ii} and d_{iii} value (36.00 per cent and 48.10 per cent,

Table 1 : Extent of heterosis over better parent and standard variety in Twenty one rice hybrids for seven characters.

Cross	Days to 50 percent flowering		Plant height (cm)		Number of productive tillers per plant		Panicle length (cm)		Number of grains per panicle		Hundred grain weight (g)		Grain yield per plant (g)	
	d_{ii}	d_{iii}	d_{ii}	d_{iii}	d_{ii}	d_{iii}	d_{ii}	d_{iii}	d_{ii}	d_{iii}	d_{ii}	d_{iii}	d_{ii}	d_{iii}
STBN 21/IR 20	-2.68**	-2.38**	-9.93**	-17.65**	8.91**	-9.75**	5.22**	-17.02**	18.41**	20.39**	1.02	-9.55**	25.14**	11.64**
STBN 21/ADT46	-3.55**	-.3.37**	-4.61**	-4.61**	3.99**	3.99**	3.94**	3.94**	36.00**	38.29**	0.91	0.91	28.04**	28.04**
STBN 21/White Ponni	-6.66**	-6.48**	-5.94**	2.51	2.56	-5.42**	-10.83**	-21.03**	20.05**	22.06**	0.51	-10.00**	26.50**	14.09**
STBN 11/IR 20	-9.02**	-8.74**	-11.39**	-18.98**	-10.87**	-26.14**	-5.66**	-25.59**	6.69**	4.22**	-15.49**	-13.18**	32.90**	10.26**
STBN 11/ADT46	-9.75**	-9.75**	-16.03**	-16.03**	-2.41	-2.41	-25.10**	-25.10**	7.59**	7.59**	-1.33	1.36	18.35**	18.35**
STBN 11/White Ponni	-9.26**	-12.75**	-31.68**	-25.55**	-6.78**	-14.03**	-19.25**	-28.49**	13.36**	10.74**	-6.64*	-4.09	19.12**	7.44**
STBN 16/IR 20	-7.99**	-7.71**	-19.51**	-26.41**	8.57**	-1.48	-1.90	-6.45**	12.58**	23.68**	-15.37**	-29.09**	12.82**	15.71**
STBN16/ADT46	-6.55**	-6.55**	-29.00**	-29.00**	16.59**	16.59**	11.09**	11.09**	34.82**	48.10**	2.27	2.27	40.63**	44.23**
STBN 16/White Ponni	-6.19**	-9.80**	-12.61**	-4.77**	13.93**	5.07**	4.10**	-0.73	19.77**	31.57**	0.59	-21.97**	20.50**	23.59**
STBN 13/IR 20	-6.92**	-6.64**	-2.01	-9.72**	-8.73**	-24.37**	-6.19**	-26.01**	11.91**	13.86**	-2.12	-15.91**	23.14**	-1.67
STBN13/ADT46	-4.54**	-4.54**	-2.73	-2.73	-4.73**	-4.73**	-25.73**	-25.73**	13.35**	15.33**	-11.36**	-11.36**	18.27**	18.27**
STBN 13/White Ponni	-1.79*	-5.57**	-29.12**	-22.76**	-4.81**	-12.21**	-20.04**	-29.18**	16.82**	18.87	-6.88*	-20.00**	18.62**	6.99**
STBN 10/IR 20	-3.64**	-3.35**	-9.41**	-17.17**	-8.14**	-23.88**	3.80*	-18.13**	1.10**	7.59**	7.23*	-22.27**	32.68**	5.95*
STBN10/ADT46	-2.41**	-2.41**	-7.90**	-7.90**	0.89	0.89	-3.91**	-3.91**	5.74**	12.52**	-21.36**	-21.36**	15.85**	15.85**
STBN 10/White Ponni	-6.58**	-6.65**	-26.94**	-20.38**	0.59	-7.24**	-1.93	-13.15**	3.89**	10.55**	-1.76	-23.79**	24.55**	12.34**
STBN 12/IR 20	-6.88**	-6.60**	-2.14	-10.53**	-5.05**	-16.64**	4.45**	-14.16**	15.99**	24.48**	-3.07	-18.79**	20.31**	14.07**
STBN 12/ADT46	-5.43**	-5.43**	-6.39**	-6.39**	10.78**	10.78**	4.29**	4.29**	32.55**	42.25**	3.79	3.79	34.51**	34.51**
STBN 12/White Ponni	-4.42**	-7.62**	-22.31**	-15.33**	8.01**	-0.39	5.63**	-6.45**	12.25**	20.46**	0.20	-22.27**	17.82**	11.71**
STBN 7/IR 20	-6.62**	-6.32**	-1.86	-10.27**	-12.89**	-27.82**	-22.35**	-38.76**	7.04**	10.64**	-2.89	-18.64**	28.29**	2.44
STBN 7/ADT46	8.07**	-8.07**	-9.15**	-9.15**	-21.47**	-21.47**	-27.68**	-27.68**	9.28**	12.96**	-4.55	-4.55	10.13**	10.13**
STBN 7/White Ponni	-2.14**	-5.90**	-6.78**	1.58	-17.08**	-23.54**	-22.20**	-31.10**	4.01**	7.51**	-0.00	-22.27**	15.85**	4.49

* Significant at 5% level ** Significant at 1% level d_{ii} – Heterobeltiosis, d_{iii} - Standard heterosis.

respectively) for this trait. Almost every hybrids showed positively significant for heterobeltiosis and standard heterosis whose value ranged from 1.10 to 36.00 per cent and 4.22 to 48.10 per cent, respectively.

For hundred grain weight the positive significant value is desirable. The cross STBN 10/IR 20 recorded the maximum significant and positive value (7.23 per cent) for heterobeltiosis. For standard heterosis negatively significant value was observed in maximum cross combinations.

For grain yield per plant the range of heterobeltiosis varied from 10.13 per cent (STBN 7/ADT 46) to 40.63 per cent (STBN 16/ADT 46). All the twenty one cross combinations recorded significant and positive heterobeltiosis. For standard heterosis the spectrum of variation ranged from 5.95 per cent (STBN 10/IR 20) to 44.23 per cent (STBN 16/ADT 46). Eighteen cross combinations out of 21 recorded significant and positive standard heterosis. Similar results were reported by Archana Devi *et al*. (2017).

Conclusion

Thus, the findings from the present study on heterosis revealed that the higher and desirable magnitude of all yield and yield attributing characters were not observed in a single cross combination. On the basis of overall performance STBN 16/ADT 46 was rated as the best since it possessed significant standard heterosis for plant height, number of productive tillers per plant, panicle length, number of grains per panicle and grain yield per plant. This hybrid found to be suitable for heterosis breeding.

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