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Research Note

Heterosis for yield and yield component traits in rice (*Oryza sativa* L.)

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Abstract

Heterosis in rice was studied for yield and its component traits in 20 F_1s involving 9 parents comprises of 4 lines and 5 testers. The high magnitude of heterosis for grain yield per plant is evident by significant superiority of crosses over mid parent and better parents in several crosses. The crosses viz. Sudu Hondarawala × PLA 1100, Sudu Hondarawala × IR 64 and Sudu Hondarawala × MTU 7029 showed high relative heterosis and heterobeltiosis for grain yield per plant. The crosses exhibiting good heterotic expression in F_1 may be further studied to isolate superior transgressive segregants in later generations. The development of pure lines from segregating population is very important for evolving high yielding varieties.

Keywords

Rice, relative heterosis, heterobeltiosis.

Rice (*Oryza sativa* L.) has been one of the world's most important food crops, feeding more than half of the world's population (Khush, 1997). In the Asia and Pacific region, rice is the main staple food. In the Indian scenario, it is estimated that rice demand in 2010 will be 100 million tonnes and in 2025, the demand will be 140 million tonnes (Mishra, 2004). This projected demand can only be met by maintaining steady increase in production over the years. The rice productivity has reached a plateau so it is thus imperative to find alternative means for increasing the yield potential of rice cultivars in a sustainable manner. So there is a need to develop high yielding varieties. This aim may be achieved by heterosis breeding by using desired lines/varieties. Heterosis breeding an important tool which can facilitate yield enhancement and helps enrich many other desirable quantitative traits in rice (Venkanna *et al*., 2014).

The magnitude of heterosis provides a basis for determining genetic diversity and also serves as a guide to the choice of desirable parents. The F_1 hybrids can be exploited commercially or can be used for selecting promising recombinants in the subsequent generations to release the best variety when it attained homozygosity (Janardhanam *et al*., 2001). In the present investigation the information on heterosis for yield and its components in twenty crosses were studied.

The present experimental material consisted of 20 F_1 crosses developed through line × tester mating design (Kempthorne, 1957) involving four lines (Sinna Sivappu, Sudu Hondarawala, PTB 33 and BM 71) and five testers (IR 64, BPT 5204, PLA 1100, MTU 7029 and MTU 1075). The crosses between lines and testers effected during *rabi* 2010-2011.

All the twenty F_1 crosses along with their parents were evaluated in randomized block design with three replications during *kharif* 2011 at Andhra Pradesh Rice Research Institute and Regional Agricultural Research Station, Maruteru. In each entry, 20 plants were maintained per replication. One month old seedlings were transplanted with a spacing of 20 cm × 15 cm. All necessary precautions were taken to maintain uniform plant population in each treatment per replication. All the recommended package of practices was followed along with necessary prophylactic plant protection measures to raise a good crop. Observations were recorded on five randomly selected plants from each entry for days to 50 per cent flowering, plant height (cm), number of ear bearing tillers, test weight (g) and grain yield per plant (g). Heterosis was estimated over mid parent and better parent and tested for significance as suggested by Snedecor and Cochran (1967).

The magnitude of heterosis is a prerequisite for development of any hybrid. Before selecting a cross on the basis of *per se* performance it would be worthwhile to evaluate them for hybrid vigour for various characters. Knowledge on the extent of heterosis would help in the choice of the best crosses for commercial exploitation.

Mean of parents and crosses are given in the Table 1. The magnitude and range of heterosis showing significant heterosis over mid parent and better parent for all the characters are presented in Table 1. PTB 33 × IR 64 was the most promising cross combination since it showed highly significant negative heterobeltiosis for days to 50 % flowering. Sudu Hondarawala × BPT 5204 recorded highly significant negative relative heterosis. Negative heterosis is a desirable feature for this character as it is useful for early maturity. Negative heterosis for this trait was reported by Hariramakrishnan *et al*. (2009), Selvaraj *et al.* (2011), Rajendra Reddy *et al*. (2012) and Srikrishna Latha *et al*. (2013). The above mentioned heterotic cross showed good *per se* performance and among the parents, Sinna Sivappu exhibited better *per se* performance.

Negative heterosis for plant height is a desirable feature as it is useful to develop dwarf types and resistance to lodging. The crosses BM 71 × MTU 7029, PTB 33 × PLA 1100, BM 71 × MTU 1075 and Sinna Sivappu × BPT 5204 were showed high significant negative heterobeltiosis. Among these crosses the cross BM 71 × MTU 7029 had shown highest significant negative heterobeltiosis. Similar results were also reported by Saravanan *et al*. (2006), Bagheri and Babaeian Jelodar (2010), Selvaraj *et al.* (2011) and Srikrishna Latha *et al*. (2013) .

For number of ear bear tillers per plant most of the hybrids showed significant positive relative heterosis and heterobeltiosis. The cross Sudhu Hondarawala × BPT 5204 exhibited the highest both significant positive relative heterosis and heterobeltisis. The results of significant positive heterosis over mid parent and better parent for number of ear bearing tillers per plant were in agreement with the results of Deo Raj *et al*. (2007), Selvaraj *et al.* (2011) and Srikrishna Latha *et al*. (2013). The *per se* performance of the above heterotic cross was high but the parents of the cross showed low *per se* performance. The heterotic performance of the cross may be due to good combining ability effect and high nicking ability of parents.

Heterosis for panicle length was most important factor in deciding grain yield. In the present study seven crosses exhibited significant positive heterosis over mid parent while four crosses showed significant positive heterosis over better parent. The crosses, BM 71 × BPT 5204 followed by BM 71 × IR 64 showed the highest positive heterosis over both mid and better parents. Similar results were earlier reported by Krishnaveni *et al*. (2005), Bagheri and Babaeian Jelodar (2010), Selvaraj *et al.* (2011) and Srikrishna Latha *et al*. (2013). Both the heterotic crosses above mentioned were recorded high *per se* performance while the parents involved in the above crosses recorded low *per se* performance. This indicated that the high heterosis may be due to good combining ability and high nicking ability of parents.

The cross PTB 33 × BPT 5204 showed highest significant positive relative heterosis where as the cross Sinna Sivappu x BPT 5204 showed both high significant positive relative heterosis and heterobeltiosis for testweight. These results were in accordance with the results of Deo Raj *et al*. (2007), Selvaraj *et al.* (2011), Srikrishna Latha *et al*. (2013) and Jarwar *et al*. (2013). The *per se* performance of the above indicated heterotic cross was high and among the parents involved in this cross Sinna Sivappu recorded high *per se* performance.

For grain yield per plant eight crosses showed significant positive relative heterosis while four crosses exhibited significant positive heterobeltiosis. The cross, Sudu Hondarawala × PLA100 recorded the highest positive heterosis over mid parent and better parent followed by Sudu Hondarawala × IR 64 and Sudu Hondarawala × MTU 7029. Similar findings were also reported by Deo Raj *et al*. (2007), Bagheri and Babaeian Jelodar (2010), Selvaraj *et al.* (2011), Rajendra Reddy *et al*. (2012), Srikrishna Latha *et al*. (2013), Jarwar *et al*. (2013) and Venkanna *et al*. (2014). These superior heterotic crosses exhibited high *per se* performance for yield. The parents involved in these heterotic crosses also exhibited higher *per se* performance except Sudu Hondarawala.

The heterosis showed variation from trait to trait. The traits no.of ear bearing tillers per plant and panicle length showed high heterobeltiosis, while the traits days to 50 % flowering and plant height at maturity exhibited high heterobeltiosis in desired direction. Mid parent heterosis for yield ranged from -11.41 % to 34.14 %. Better parent heterosis for yield ranged between -26.0 5 % and 19.02 %.

In conclusion based on the overall performance (*per se* performance and high significant positive relative heterosis and heterobeltiosis) the cross Sudu Hondarawala × MTU 7029 was identified as the most promising cross. This cross may be further advanced to isolate superior transgressive segregants for yield and yield contributing traits.

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Table 1. *Per se* performance of parents and crosses for different characters of rice

Parent/ cross	Days to 50 % flowering	Plant height at maturity	No. of ear bearing tillers/plant	Panicle length (cm)	Test weight (g)	Grain yield (g)
Sinna Sivappu	96	175.42	6.50	30.16	22.30	16.13
Sudu Hondarawala	123	128.40	6.90	28.17	20.03	19.11
PTB 33	130.33	177	6.63	26.18	26.27	17.93
BM 71	113.67	163.67	7.20	24.22	20.43	19.96
IR 64	87	111.67	9.17	25.33	26.03	24.21
BPT 5204	120	110.87	8.10	23.46	15.53	21.11
PLA 1100	122	122.40	8.20	27.13	19.10	23.36
MTU 7029	116	112.6	7.7	24.97	19.87	23.36
MTU 1075	110.67	124.60	8.0	28.40	22.63	25.15
Sinna Sivappu × IR 64	98.67	163.21	8.4	26.67	22.07	25.60
Sinna Sivappu × BPT 5204	104.67	157.07	7.07	26.80	23.40	20.30
Sinna Sivappu × PLA 1100	104	172.47	8.5	25.54	22.07	26.70
Sinna Sivappu × MTU 7029	97.67	166.40	8.43	27.61	21.13	17.49
Sinna Sivappu × MTU 1075	96	163.17	7.23	29.17	21.30	18.6
PTB 33 × IR 64	108	163.17	7.23	29.17	21.30	18.6
PTB 33 × BPT 5204	124.67	163.4	8.4	28.51	26	20.57
PTB 33 × PLA 1100	126	156.83	7.73	24.33	22.10	19.45
PTB 33 × MTU 7029	129.33	175.8	9.1	28.01	24.2	21.61
PTB 33 × MTU 1075	121.33	172.63	10.07	30.06	22.93	22.73
Sudu Hondarawala × IR 64	108.67	127.17	7.20	24.60	20.23	27.44
Sudu Hondarawala × BPT 5204	111	125.77	10.50	27.27	17.27	23.33
Sudu Hondarawala × PLA 1100	127	124.97	8.3	27.64	19.33	29.37
Sudu Hondarawala × MTU 7029	118	123.63	9.03	26.77	20.07	26.37
Sudu Hondarawala × MTU 1075	117.67	126.83	8.30	30.23	18.47	21.99
BM 71 × IR 64	107	155.19	8.33	32.07	20.50	24.24
BM 71 × BPT 5204	113	145.27	8.07	31.27	19.17	22.85
BM 71 × PLA 1100	115.33	150.63	8.27	30.10	20.17	25.67
BM 71 × MTU 7029	117.67	144.68	7.47	29.34	19.33	20.39
BM 71 × MTU 1075	113	146	10.27	27.81	20.37	22.48

Table 2. Estimates of heterosis over mid parent (MP) and better parent (BP) in per cent for different characters in rice

Cross	Days to 50 % flowering		Plant height at maturity(cm)		No. of ear bearing tillers/plant		Panicle length (cm)		Test weight (g)		Grain yield (g)	
	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP
Sinna Sivappu × IR 64	7.83**	2.78	13.70**	-6.96	7.23	8.36*	-3.90	-11.59*	-8.69**	-15.24	26.90**	5.73
Sinna Sivappu × BPT 5204	-3.09*	-12.78**	9.73*	-10.46*	-3.20	-12.76**	-0.40	-11.15*	23.70**	4.93*	9.00	-3.85
Sinna Sivappu × PLA 1100	-4.59**	-14.75**	15.82**	-1.68	15.65**	3.66	-10.84*	-15.33**	6.60**	-1.05	30.86**	8.21
Sinna Sivappu × MTU 7029	-7.86**	-15.80**	15.55**	-5.14	18.78**	9.52	0.18	-8.45	0.24	-5.23*	-11.41	-25.11**
Sinna Sivappu × MTU 1075	-7.10**	-13.25**	8.77*	-6.98	-0.23	-9.58	-0.39	-3.30	-5.19*	-5.89*	-9.90	-26.05**
PTB 33 × IR 64	-0.61	-17.14**	13.46**	7.48	31.22**	13.09**	19.27**	17.34**	-5.93**	-6.35**	17.07**	1.87
PTB 33 × BPT 5204	-0.40	-4.35**	13.52**	7.68	14.03**	3.70	14.85**	8.89	24.40**	-1.02	5.36	-2.59
PTB 33 × PLA 1100	-0.13	-3.32*	4.77	11.39*	4.27	-5.69	-8.72	-10.31	-2.57	-15.86**	-8.70	-21.18**
PTB 33 × MTU 7029	5.01**	-0.77	21.41**	0.68	26.98**	18.18**	9.53	6.99	4.91*	-7.87**	4.67	-7.51
PTB 33 × MTU 1075	0.69	-6.91**	14.48**	2.47	37.59**	25.83**	10.16*	5.86	-6.20**	-12.69**	5.54	-9.62
Sudu Hondarawala × IR 64	2.52	-13.07**	5.94	0.96	-10.37*	-21.45**	-8.05	-12.67*	-12.16**	-22.28**	26.67**	13.33*
Sudu Hondarawala × BPT 5204	-9.39**	-11.20**	5.13	-2.05	40.00**	29.63**	5.63	-3.20	-2.91	-13.81**	15.98*	10.48
Sudu Hondarawala × PLA 1100	2.83*	1.60	-0.35	-2.67	9.93*	1.22	-0.02	-1.87	-1.19	-3.49	34.14**	19.02**
Sudu Hondarawala × MTU 7029	-2.07	-5.60**	2.60	-3.71	23.74**	17.32**	0.77	-4.96	0.58	0.17	24.19**	12.90*
Sudu Hondarawala × MTU 1075	-0.14	-5.87**	0.26	-1.22	11.41*	3.75	6.90	6.47	-13.44**	-18.14**	-0.63	-12.56*
BM 71 × IR 64	6.64**	-5.87**	12.73*	-5.18	1.83	-9.09*	29.43**	26.58**	-11.76**	-21.25**	9.57	0.11
BM 71 × BPT 5204	-3.28*	-5.83**	5.83	-11.24	5.45	-0.41	31.16**	29.11**	6.58*	-6.20*	11.28	8.24
BM 71 × PLA 1100	-2.12	-5.46**	5.31	-7.96	7.36	0.81	17.25**	10.96	2.02	-1.31	15.01**	4.03
BM 71 × MTU 7029	2.47	1.44	4.74	-11.60*	0.22	-3.03	19.32**	17.53**	-4.05	-5.38*	-4.49	-11.44
BM 71 × MTU 1075	0.74	-5.09	1.65	-10.48	35.09**	28.33**	5.71	-2.07	-5.42*	-10.01**	-0.34	-10.63

*, ** = Significant at 5 % and 1 % level, respectively. MP- Mid parent BP- Better parent