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Heterosis for yield and yield contributing characters in rice (*Oryza sativa* L.)

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Abstract
An investigation was taken up to study the magnitude of heterosis for nine characters in rice *viz.*, days to 50 percent flowering, days to maturity, plant height at maturity, productive tillers per plant, tillers per square meter, thousand grain weight, grains per panicle, and yield per plant. The base material for this experiment consisted of 36 F1s involving three cytoplasmic male sterile lines (CMS) and twelve diverse restorers in line x tester mating design along with best varietal check Phule Samruddhi and best hybrid check Sahyadri-4. Hybrids were evaluated in randomized block design (RBD) with three replications. Heterosis over mid parent, better parent and standard checks revealed that experimental hybrids had higher heterotic effect for all the characters under study. The estimates of heterosis revealed that, there was a large amount of better parent and check parent 102 heterosis thus RTN17-A x RPHR51, RTN6-A x IR40750, RTN17-A x RPHR2, RTN6-A x RPHR51, RTN6-A x IR66, IR58025 x IR61614, RTN17-A x IR61614 and RTN17-A x IR60199 were found to be most promising hybrids. The crossing of exotic male sterile lines with local restorers appears to be the right approach in getting heterotic combinations.

Keywords: heterosis, hybrid vigor, rice, *Oryza sativa* L.

Introduction
To provide sufficient food in rice growing countries, breeders have developed several promising varieties with different maturity groups having disease and pest resistance. However, these straight varieties fall short in fulfilling the demand for ever increasing population. The development of semi dwarf rice varieties has revolutionized rice cultivation. The varieties were derived from dee-geo-woo-gene, a dwarf early maturing variety of Japonica rice from Taiwan.
The rice productivity is increased due to introduction of such high yielding dwarf rice varieties responsive to high doses of fertilizers coupled with improved packages of practices.
The situation warranted for a new approach to boost the yield of rice. The concept of heterosis through use of cytoplasmic male sterility hope to boost the production in rice. Finding new sources of cytoplasmic male sterility is a difficult task. However, the national and international institutes like CRRI, Cuttack and IRRI, Philippines, respectively provided easy access to the availability to different CMS sources in India. The Wild Abortive (WA) CMS source has been used extensively in India. Presently, the other CMS sources *viz.*, Gambiaca, ARC, Mutant 14 Basmati and Dissi are being used. This will avoid the ill effects of monoculturing of rice varieties. This necessitated the need to develop rice hybrids with high yielding potential. The performance of these hybrids depend upon the response of various quantitative characters in different seasons. Testing the performance of such hybrids under different seasons of their growth is necessary as different components of environment as requirement of photo and thermal units play important role in crop production.
The first step in generating promising hybrids is the Selection of desirable parents. The contribution of parents in a cross and *nick well* ability of parents in crosses can be assessed by biometrical methods through combining ability studies. The studies on heterosis can indicate the increase of performance of crosses over parents. The exploitation of heterosis is considered an outstanding application of the principles of the science of genetics in agriculture. Heterosis breeding had led to a breakthrough in yield in several crop plants. For the exploitation of heterosis, it is imperative to study the magnitude of heterosis. The expression of heterosis is greatly influenced by the magnitude of genetic differences among parents involved in the crosses. The parents with optimal to intermediate genetic diversity will show maximum heterosis.

Materials and Methods
The experimental material consist of three female lines and twelve restorers crossed in

line x tester fashion to produce 36 hybrids. The resulting 36 hybrids, 15 parents and 2 checks includes one varietal and one hybrid checks were studied in randomized block design with three replications during *kharif* 2013 at Agriculture Research Station Vadgaon Maval, Pune. Each plot consisted of single row of 3.0 meter length with a spacing of 20 cm. between rows and 15 cm. within plant.

The recommended dose of fertilizer was applied @ 100:50:50 kg NPK/ha splits to 50 per cent of N and full dose of P and K at transplanting, 25 per cent of N at 30 DAT and 25 per cent of N at 60 DAT. The recommended cultural practices including weeding, fertigation and plant protection measures were followed as per recommendation Heterosis was calculated as per procedure suggested by Shull (1914) [11].

Results and Discussions

In the present study, superiority of the hybrids was estimated over mid-parent; better parent and standard check (varietal and hybrid) for all the eight characters. The range of heterosis over mid-parent, better parent and standard checks and promising crosses with heterosis in respect of each of the character.

Days to 50 per cent flowering (No.)

The number of days required for 50 per cent of the plants in a genotype to flower is a definite indication of the duration of the genotype. Days to maturity is often closely correlated with days to flowering, although genetic differences in the period or duration required for flowering to maturity exists. Thus, genetic information relative to flowering date may also apply to maturity date.

From Table 1, it is quite evident that RTN17-A x PRHR2, RTN6-A x IR40750, crosses showed significant negative heterosis over mid parent and better parent respectively and RTN17A x RPHR51 showed significant negative heterosis over both the checks suggesting earliness of flowering. The hybrid RTN6A x IR40750 had highest negative heterobeltiosis value. However, the hybrid RTN17A x RPHR51 and RTN17A x RPHR2 exhibited significant negative standard heterosis over the best checks. The negative heterosis also substantiated the fact that the hybrids in general were early in flowering. The existence of both significant positive and negative heterotic effects over parents and checks suggests the presence of non-additive gene action for this trait. Sampath *et al*. (1989) [10], Ramlingam *et al.* (1993), Manonmani and Ranganathan (1996) [8] and Bhandarkar *et al.* (2005) [2] have also reported earliness in rice hybrids.

Days to maturity (No.)

From Table 1, it is quite evident that cross RTN6-A x IR40750 showed significant negative heterosis over mid parent and better parent, RTN 6A x IR66 showed significant negative heterosis over both the checks suggesting early maturity in hybrids. The hybrid RTN6-A x IR40750 had the highest significant negative heterosis over mid-parent, better-parent and RTN 6A x IR66 had the highest significant negative standard heterosis. In general, the hybrids derived with RTN 6-A and IR58025-A as the female parent had highest negative heterosis over all the check hybrids. The hybrids derived from these lines were observed to mature two to three days earlier than their parents.

The existence of significant heterotic effect over parents and checks suggested the presence of non-additive gene action and dominance for this trait. Li *et al*. (2002) [7], Bhave *et al.* (2002) [3], Khrishna Veni and Shobharani (2003) [5] and Alam *et al.* (2004) [1] have also reported early maturity in hybrids.

Plant height (cm)

In the present study, most of the hybrids exhibited heterosis in negative direction. From the table 1 it is evident that, hybrids such as RTN17-A x RPHR2 recorded significant negative heterosis over mid parent and hybrid check while RTN17-A x RPHR1005 recor ded significant negative heterosis over better parent and standard varietal check; indicating that experimental hybrids were dwarf than their parents and standard checks.

This phenomenon was in agreement with reports of Alam *et al.* (2004) [1], Li *et al.* (2002) [7], Krishna veni and Shobharani (2003) [5] and Krishna Veni *et al.* (2005) [6].

Productive tillers per plant (No.)

Productive tillers is one of the yield contributing character. In present investigation attempt has been made to establish relationship between productive tillers per plant and yield. For this the total number of panicle bearing tillers were counted. Hybrid exhibited intermediate expression for productive tillers per plant. However from the table 1 it is observed that hybrid RTN17-A x IR60199 and RTN17-A x IR62037 recorded significant positive heterosis over mid-parent, better parent and standard checks. Similar results were observed by Sampath *et al*. (1989) [10] Krishna Veni and Shobha Rani (2003) [5], Krishna Veni *et al.* (2005) [6] and Bhandarkar *et al*. (2005) [2].

Productive tillers per square meter (No.)

Although there are many tillers per square meter, some of them do not contribute to yield. Therefore productive tillers per square meter form an important yield component that varies among genotypes. Among the experimental hybrids, twenty seven hybrids showed significant positive heterosis for productive tillers per square per meter over mid-parent and eighteen hybrids showed significant positive heterosis over better-parent, indicating the presence of non-additive and over dominance gene action. On contrary to this from the table 5 it is evident that hybrids RTN17-A x IR60199 exhibited significant positive heterosis over the mid parents, better parent and both the check. Similar results were observed by Krishna Veni and Shobha Rani (2003) [5], Alam *et al*. (2004) [1] and Yadav *et al*. (2004) [14].

Test weight (1000 grain weight (g))

The thousand seeds weight of a genotype serves as an indicator of seed yield as it is an important character contributing to yield. In the present investigation, highly significant positive heterosis over mid-parent was recorded. However, majority of the hybrids recorded negative significant heterosis over the better-parent. From the table 1 it is observed that hybrid IR580258A x IR60199 exhibited the highest mid-parent heterosis and RTN6-A x RPHR51 recorded highest heterosis over better parent while IR58025-A x RPHR612 recorded highest standard heterosis. In general, the hybrid combinations with RTN6–A and IR58025-A as the female parent recorded highest positive heterotic values over the best check. This suggested the preponderance of dominant gene action in the determination of this trait. The significant positive heterosis for test weight is in conformity with the reports of Li *et al.* (2002) [7], Singh *et al*. (2006) [12], Singh *et al.* (2007) [13].

Grains per panicle (No)

Total number of grains per panicle is one of the important yield contributing character. In the present investigation attempt has been made to establish relationship between total number of grains per panicle, for this total number of grains per panicle were counted. Majority of hybrids recorded significant positive heterosis over best check indicates presence of non-additive gene action.

The hybrid RTN17-A x IR61614 exhibited significant positive heterosis over mid-parent. Hybrid IR58025-A x RPHR2 recorded significant positive heterosis over better parent while IR58025-A x IR61614 recorded significant positive heterosis over both the checks. Among the female parent, crosses involving RTN6-A and RTN17-A exhibited higher heterosis over checks. The standard heterosis involving IR61614, RPHR2, RPHR51 as male parent was appreciably high than those involving other tester parents. The hybrids IR58025-A x IR61614, RTN-17 x IR61614 and IR58025-A x RPHR2 displayed highest standard heterosis over standard checks compared to other crosses this cross combination worth for commercial exploitation after large scale evaluation over different environments. Similar results were reported by and Chamundeswari *et al.* (2012) [4].

Yield per plant (g)

A number of the research workers reported significant positive heterotic effects for seed yield. Seed yield per plant under well managed conditions would serve as a pointer to seed yield per unit area. Out of thirty six hybrids, thirty hybrids recorded significant positive heterosis over mid parent. This suggests a strong influence of non-additive gene action in determining seed yield per plant. Hybrids such as RTN6-A x RPHR1096, RTN6-A x BR827-35 recorded positive heterosis over mid-parent and better parent, respectively while RTN6-A x IR40750, IR58025-A x IR61614 over standard checks. The predominance of non-additive type of gene action for seed yield per plant favours for the development of potential high yielding hybrids. Similar conclusions were drawn by Sampath *et al.* (1989) [10], Ramalingam *et al*. (1993) [9], Manonmani and Ranganathan (1996) [8], Chamundeswari *et al.*(2012) [4].

Table 1: Heterosis over different characters

S. N.	Crosses	Days to 50% flowering				Days to maturity			
		MP	BP	SCV	SCH	MP	BP	SCV	SCH
1	IR58025A x IR40750	-2.68**	-5.83**	-1.69	-2.68**	-4.94**	-10.07**	-2.34**	-3.85**
2	IR58025A x IR66	2.52**	-0.33	3.04**	2.01*	2.46**	-1.00	2.86**	1.28
3	IR58025A x IR60199	-1.49	-5.41**	0.33	-0.67	0.13	-4.18**	1.56	0
4	IR58025A x IR61614	3.57**	1.67	3.04**	2.00*	6.09**	4.43**	4.43**	2.82**
5	IR58025A x BR827-35	3.95**	3.06**	2.36**	1.33	3.94**	1.54**	3.13**	1.54
6	IR58025A x IR62037	3.37**	0.66	3.71**	2.67**	9.66**	6.61**	9.38**	7.69**
7	IR58025A x RPHR1005	2.89**	1.00	2.36**	1.33	1.86	0.52	0	-1.54
8	IR58025A x RPHR51	7.39**	5.54**	3.04**	2.00*	5.30**	4.03**	0.78	-0.77
9	IR58025A x RPHR619	2.69**	0.00	3.04**	2.00*	4.96**	2.03*	4.69**	3.077**
10	IR58025A x RPHR2	4.83**	4.47**	2.69**	1.67	21.05**	12.09**	8.59**	6.92**
11	IR58025A x RPHR1096	6.83**	5.54**	3.04**	2.00*	3.67**	2.41**	-0.78	-2.31**
12	IR58025A x RPHR612	3.29**	3.11**	0.67	-0.34	7.55**	7.26**	3.91**	2.31**
13	RTN6A x IR40750	-4.57**	-8.74**	-4.73**	-5.69**	-6.41**	-10.79**	-3.13**	-4.62**
14	RTN6A x IR66	0.34	-3.60**	-0.34	-1.34	-5.02**	-7.51**	-3.91**	-5.38**
15	RTN6A x IR60199	-0.67	-5.73**	-0.003	-1.01	-0.64	-4.18**	1.56	0
16	RTN6A x IR61614	1.03	-2.00*	-0.67	-1.67	3.41**	2.60**	2.60**	1.03
17	RTN6A x BR827-35	4.86**	2.72**	2.02*	1.00	4.43**	2.82**	4.43**	2.82**
18	RTN6A x IR62037	4.94**	0.98	4.05**	3.01**	6.48**	4.31**	7.03**	5.38**
19	RTN6A x RPHR1005	2.40**	-0.67	0.67	-0.34	2.63**	2.09*	1.56	0
20	RTN6A x RPHR51	8.02**	7.43**	2.36**	1.33	4.72**	2.65**	1.04	-0.51
21	RTN6A x RPHR619	2.56**	-1.31	1.69	0.67	2.85**	0.76	3.39**	1.79
22	RTN6A x RPHR2	5.06**	3.44**	1.69	0.67	16.55**	7.14	5.47**	3.84**
23	RTN6A x RPHR1096	8.16**	8.16**	3.03**	2.00*	10.12**	8.26*	7.94	6.25
24	RTN6A x RPHR612	5.61**	4.51**	1.69	0.67	8.29**	7.14**	5.47**	3.85**
25	RTN17A x IR40750	-0.98	-2.27*	2.02*	1.00	-1.12	-4.32**	3.90**	2.31**
26	RTN17A x IR66	1.81	0.98	4.39**	3.34**	3.68**	2.51**	6.51**	4.87**
27	RTN17A x IR60199	-2.11*	-4.14**	1.69	0.67	-1.88	-3.93**	1.82	0.26
28	RTN17A x IR61614	5.16**	4.98**	6.75**	5.68**	6.20**	5.39**	7.03**	5.38
29	RTN17A x BR827-35	0.50	-0.66	1.01	-0.003	1.80	1.79	3.39**	1.79
30	RTN17A x IR62037	1.98*	1.31	4.39**	3.34**	3.32**	2.79**	5.47**	3.85**
31	RTN17A x RPHR1005	-3.83**	-3.99**	-2.37**	-3.35**	2.59**	1.54	3.13**	1.54
32	RTN17 A x RPHR51	-3.79**	-7.31**	-5.74**	-6.69**	-1.46	-4.87**	-3.39**	-4.87**
33	RTN17A x RPHR619	2.64**	1.97*	5.06**	4.01**	2.29**	1.78	4.43**	2.82**
34	RTN17A x RPHR2	-5.07**	-6.65**	-5.07**	-6.02**	8.63**	-1.54	0	-1.54
35	RTN17A x RPHR1096	6.00**	2.66**	4.39**	3.34**	5.98**	2.31**	3.91**	2.31**
36	RTN17A x RPHR612	5.60**	3.32**	5.06**	4.01**	8.95**	6.15**	7.81**	6.15**

S. N.	Crosses	Plant height				Tillers per plant			
		MP	BP	SCV	SCH	MP	BP	SCV	SCH
1	IR58025A x IR40750	26.00**	24.78**	-4.84**	6.50**	-1.70	-4.28**	-2.55**	5.94**
2	IR58025A x IR66	27.12**	22.41**	0.83	12.85**	5.33**	1.44	-2.14*	6.40**
3	IR58025A x IR60199	48.63**	43.19**	9.21**	22.23**	15.84**	2.88**	-0.77	7.88**
4	IR58025A x IR61614	33.99**	33.18**	1.57	13.68**	5.01**	2.54**	3.80**	12.86**
5	IR58025A x BR827-35	50.11**	41.85**	21.55**	36.05**	15.17**	2.88**	-0.77	7.88**
6	IR58025A x IR62037	39.47**	35.98**	9.16**	22.18**	-6.10**	-17.86**	-20.80**	-13.88**
7	IR58025A x RPHR1005	13.00**	-1.37	0.87	12.90**	1.40	-3.08**	-6.54**	1.61
8	IR58025A x RPHR51	27.05**	18.30**	4.62**	17.10**	-3.43**	-7.60**	-10.87**	-3.10**
9	IR58025A x RPHR619	11.93**	7.76**	-11.17**	-0.58	-5.06**	-7.60**	-10.87**	-3.10**
10	IR58025A x RPHR2	127.25**	118.61**	80.45**	101.97**	9.11**	-4.11**	-7.49**	0.58
11	IR58025A x RPHR1096	105.82**	96.17**	49.61**	67.45**	-16.28**	-18.48**	-16.99**	-9.75**
12	IR58025A x RPHR612	19.26**	14.90**	-5.45**	5.82**	-4.32**	-8.29**	-3.57**	4.84**
13	RTN6A x IR40750	11.43**	10.09**	-17.67**	-7.85**	-12.21**	-18.87**	-17.40**	-10.21**
14	RTN6A x IR66	13.23**	6.78**	-12.04**	-1.55	4.62**	2.88**	-8.14**	-0.13
15	RTN6A x IR60199	51.96**	49.55**	9.16**	22.18**	2.21**	-4.59**	-17.65**	-10.47**
16	RTN6A x IR61614	53.41**	51.01**	13.79**	27.36**	2.22**	-5.28**	-4.16**	4.20**
17	RTN6A x BR827-35	9.21**	1.12	-13.35**	-3.018**	16.97**	9.86**	-5.11**	3.17**
18	RTN6A x IR62037	31.17**	25.22**	0.52	12.51**	19.85**	10.09**	-4.93**	3.36**
19	RTN6A x RPHR1005	7.84**	-7.59**	-5.49**	5.77**	18.18**	17.12**	2.97**	11.96**
20	RTN6A x RPHR51	25.51**	14.55**	1.31	13.39**	20.55**	19.33**	5.17**	14.34**
21	RTN6A x RPHR619	64.19**	54.76**	27.62**	42.84**	2.34**	-0.43	-9.09**	-1.17
22	RTN6A x RPHR2	63.25**	53.81**	26.96**	42.10**	14.04**	5.28**	-9.09**	-1.17
23	RTN6A x RPHR1096	42.09**	38.31**	0.96	13.00**	6.11**	-1.95	-0.18	8.53**
24	RTN6A x RPHR612	13.29**	6.89**	-12.04**	-1.55	-0.10	-9.04**	-4.34**	4.01**
25	RTN17A x IR40750	70.05**	64.29**	22.86**	37.51**	4.60**	-9.34**	-7.72**	0.32
26	RTN17A x IR66	34.25**	23.94**	2.09*	14.26**	14.01**	4.67**	-6.54**	1.61
27	RTN17A x IR60199	44.38**	43.40**	1.35	13.44**	41.72**	41.53**	5.94**	15.18**
28	RTN17A x IR61614	30.95**	26.06**	-5.02**	6.31**	8.11**	-6.07**	-4.93**	3.36**
29	RTN17A x BR827-35	23.02**	11.56**	-4.41**	6.99**	38.16**	37.08**	3.98**	13.05**
30	RTN17A x IR62037	47.53**	37.83**	10.65**	23.84**	36.39**	34.22**	0.24	8.98**
31	RTN17A x RPHR1005	-3.80**	-19.11**	-17.28**	-7.41**	16.69**	7.88**	-5.11**	3.17**
32	RTN17 A x RPHR51	20.17**	7.45**	-4.97**	6.36**	9.00**	0.67	-11.29**	-3.55**
33	RTN17A x RPHR619	32.91**	22.65**	1.13	13.20**	16.71**	6.07**	-3.15**	5.30**
34	RTN17A x RPHR2	-9.40**	-16.44**	-31.02**	-22.80**	34.32**	32.89**	-0.77	7.88**
35	RTN17A x RPHR1096	26.71**	26.16**	-12.04**	-1.55	-4.38**	-17.12**	-15.63**	-8.27**
36	RTN17A x RPHR612	32.95**	22.80**	1.05	13.10**	4.63**	-10.55**	-5.94**	2.26

S. N.	Crosses	Tillers per sq. meter				1000 grain weight			
		MP	BP	SCV	SCH	MP	BP	SCV	SCH
1	IR58025A x IR40750	-1.70	-4.28**	-2.72**	6.05**	24.87**	13.83**	0.30	-0.55
2	IR58025A x IR66	5.33**	1.44	-2.33**	6.48**	16.28**	-3.54**	-15.00**	-15.72**
3	IR58025A x IR60199	15.84**	2.88**	-0.94	7.99**	47.86**	19.45**	5.26**	4.37**
4	IR58025A x IR61614	5.01**	2.54**	3.60**	12.95**	32.24**	29.26**	13.90**	12.94**
5	IR58025A x BR827-35	15.16**	2.86**	-0.95	7.97**	14.72**	3.38**	-8.91**	-9.68**
6	IR58025A x IR62037	-6.10**	-17.86**	-20.91**	-13.78**	6.32**	4.18**	-8.20**	-8.96**
7	IR58025A x RPHR1005	1.40	-3.08**	-6.68**	1.74	18.39**	-4.98**	-16.28**	-16.98**
8	IR58025A x RPHR51	-3.43**	-7.60**	-11.02**	-3.00**	38.70**	28.78**	13.47**	12.52**
9	IR58025A x RPHR619	-5.06**	-7.60**	-11.02**	-3.00**	12.60**	4.18**	-8.20**	-8.98**
10	IR58025A x RPHR2	8.99**	-4.10**	-7.66**	0.66	10.62**	0.48	-11.46**	-12.21**
11	IR58025A x RPHR1096	-16.28**	-18.48**	-17.15**	-9.69**	23.72**	-0.64	-12.45**	-13.19**
12	IR58025A x RPHR612	-4.23**	-8.11**	-3.71**	4.97**	31.85**	26.40**	21.41**	20.38**
13	RTN6A x IR40750	-12.21**	-18.87**	-17.55**	-10.12**	11.89**	9.09**	-16.70**	-17.40**
14	RTN6A x IR66	4.62**	2.88**	-8.26**	0.013	19.49**	5.20**	-19.68**	-20.35**
15	RTN6A x IR60199	2.21*	-4.59**	-17.75**	-10.33**	21.69**	4.08**	-20.58**	-21.20**
16	RTN6A x IR61614	2.24*	-5.27**	-4.29**	4.34**	37.16**	30.81**	10.07**	9.14**
17	RTN6A x BR827-35	16.97**	9.86**	-5.29**	3.25**	22.93**	18.37**	-9.62**	-10.38**
18	RTN6A x IR62037	19.85**	10.09**	-5.09**	3.46**	13.03**	7.54**	-9.05**	-9.82**
19	RTN6A x RPHR1005	18.19**	17.13**	2.81**	12.08**	41.49**	20.22**	-8.20**	-8.98**
20	RTN6A x RPHR51	20.55**	19.33**	4.99**	14.45**	46.27**	45.46**	11.06**	10.13**
21	RTN6A x RPHR619	2.34*	-0.43	-9.25**	-1.07	17.23**	16.14**	-11.32**	-12.06**
22	RTN6A x RPHR2	13.90**	5.28**	-9.25**	-1.07	22.06**	18.55**	-9.48**	-10.24**
23	RTN6A x RPHR1096	6.11**	-1.95	-0.35	8.63**	33.19**	13.17**	-13.59**	-14.32**
24	RTN6A x RPHR612	0.00	-8.87**	-4.50**	4.11	35.91**	21.98**	17.16**	16.17**
25	RTN17A x IR40750	5.26**	-8.77**	-7.28**	1.08	21.19**	15.60**	-7.64**	-8.42**

26	RTN17A x IR66	14.01**	4.66**	-6.68**	1.74	59.14**	37.41**	9.79**	8.86**
27	RTN17A x IR60199	41.72**	41.53**	5.78**	15.32**	32.42**	11.17**	-11.18**	-11.93**
28	RTN17A x IR61614	8.11**	-6.07**	-5.09**	3.46**	43.87**	40.24**	18.01**	17.01**
29	RTN17A x BR827-35	38.16**	37.08**	3.80**	13.16**	16.28**	9.57**	-12.45**	-13.19**
30	RTN17A x IR62037	36.39**	34.22**	0.05	9.07**	2.84**	0.000	-15.43**	-16.14**
31	RTN17A x RPHR1005	16.70**	7.90**	-5.29**	3.25**	17.96**	-1.60	-21.38**	-22.04**
32	RTN17 A x RPHR51	9.00**	0.67	-11.42**	-3.44**	45.85**	41.84**	13.33**	12.38**
33	RTN17A x RPHR619	16.71**	6.07**	-3.31**	5.40**	-0.27	-3.37**	-22.79**	-23.44**
34	RTN17A x RPHR2	34.14**	32.89**	-0.94	7.99**	36.94**	30.14**	3.98**	3.11**
35	RTN17A x RPHR1096	-4.41**	-17.15**	-15.80**	-8.21**	26.04**	5.14**	-15.99**	-16.70**
36	RTN17A x RPHR612	4.72**	-10.40**	-6.11**	2.36**	31.72**	20.65**	15.88**	14.91**

S. No.	Crosses	No. of grains per plant				Yield per plant			
		MP	BP	SCV	SCH	MP	BP	SCV	SCH
1	IR58025A x IR40750	-7.91**	-18.99**	34.78**	12.30**	14.31**	9.10**	8.36**	1.80
2	IR58025A x IR66	-37.41**	-41.86**	-26.54**	-38.79**	-7.85**	-12.92**	-14.14**	-19.34**
3	IR58025A x IR60199	-10.01**	-17.91**	3.71**	-13.59**	-10.39**	-14.59**	-15.78**	-20.88**
4	IR58025A x IR61614	17.45**	12.12**	55.79**	29.81**	18.02**	15.67**	14.05**	7.14**
5	IR58025A x BR827-35	-42.56**	-50.38**	-13.85**	-28.22**	-8.81**	-18.51**	-19.65**	-24.52**
6	IR58025A x IR62037	7.34**	6.24**	34.23**	11.84**	-3.94**	-8.47**	-9.76**	-15.22**
7	IR58025A x RPHR1005	4.41**	-9.05**	14.91**	-4.25**	6.22**	0.59	-0.89	-6.82**
8	IR58025A x RPHR51	8.08**	-1.99*	52.19**	26.81**	8.30**	7.57**	7.50**	1.00
9	IR58025A x RPHR619	5.46**	-4.99**	20.04**	0.016	16.28**	2.81**	1.38	-4.76**
10	IR58025A x RPHR2	26.14**	19.07**	50.44**	25.35**	25.53**	10.25**	8.70**	2.12**
11	IR58025A x RPHR1096	-28.70**	-31.99**	-14.08**	-28.41**	38.56**	2.54**	1.10	-5.02**
12	IR58025A x RPHR612	6.56**	-5.53**	54.37**	28.62**	5.31**	1.92	7.40**	0.90
13	RTN6A x IR40750	-15.13**	-30.29**	15.98**	-3.37**	35.25**	24.84**	13.60**	6.72**
14	RTN6A x IR66	-2.42**	-3.08**	5.065**	-12.46**	31.77**	23.69**	8.53**	1.96*
15	RTN6A x IR60199	-9.11**	-10.28**	-4.06**	-20.06**	20.49**	12.15**	0.21	-5.86**
16	RTN6A x IR61614	26.63**	12.04**	55.68**	29.71**	22.95**	11.47	5.52**	-0.87
17	RTN6A x BR827-35	-25.33**	-39.68**	4.74**	-12.73**	42.27**	41.70**	9.97**	3.31**
18	RTN6A x IR62037	-12.96**	-18.89**	0.39	-16.35**	9.25**	1.73	-9.17**	-14.67**
19	RTN6A x RPHR1005	0.00	-6.15**	0.36	-16.38**	16.46**	9.09**	-3.83**	-9.65**
20	RTN6A x RPHR51	11.35**	-5.99**	45.99**	21.63**	14.25**	1.13	1.07	-5.05**
21	RTN6A x RPHR619	-15.21**	-17.44**	-11.71**	-26.44**	26.05**	25.04**	-3.73**	-9.56**
22	RTN6A x RPHR2	-2.78**	-5.06**	6.51**	-11.25**	20.24**	18.37**	-8.87**	-14.38**
23	RTN6A x RPHR1096	-4.79**	-8.01**	5.48**	-12.11**	55.92**	25.89**	-3.08**	-8.94**
24	RTN6A x RPHR612	13.88**	-5.81**	53.91**	28.24**	22.63**	6.11**	11.82**	5.051**
25	RTN17A x IR40750	-6.47**	-18.75**	35.18**	12.63**	22.64**	19.46**	8.70**	2.12**
26	RTN17A x IR66	-6.22**	-11.68**	8.36**	-9.71**	22.02**	20.10**	6.17**	-0.26
27	RTN17A x IR60199	-11.22**	-17.92**	0.70	-16.10**	10.84**	8.93**	-2.67**	-8.56**
28	RTN17A x IR61614	21.87**	14.74**	59.43**	32.84**	22.92**	17.48**	11.20**	4.47**
29	RTN17A x BR827-35	-34.58**	-44.19**	-3.09**	-19.25**	19.62**	13.62**	-1.99*	-7.92**
30	RTN17A x IR62037	-21.05**	-21.39**	-2.71**	-18.94**	4.84**	3.07**	-7.98**	-13.55**
31	RTN17A x RPHR1005	-13.32**	-23.53**	-6.17**	-21.83**	17.34**	16.08**	2.33**	-3.86**
32	RTN17 A x RPHR51	9.93**	-1.61	52.79**	27.30**	20.54**	12.30**	12.23**	5.44**
33	RTN17A x RPHR619	-3.86**	-12.24**	7.68**	-10.29**	33.33**	25.21**	8.02**	1.48
34	RTN17A x RPHR2	-11.59**	-15.37**	3.83**	-13.49**	14.29**	6.55**	-8.08**	-13.64**
35	RTN17A x RPHR1096	-1.16	-4.39**	17.31**	-2.27**	44.48**	11.87**	-3.49**	-9.33**
36	RTN17A x RPHR612	7.96**	-5.49**	54.43**	28.67**	16.51**	5.95**	11.64**	4.89**

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