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Performance of parents and their hybrids in rice (*Oryza sativa* L.)

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Abstract
The present investigation was carried out at the Experimental farm of Regional Agriculture Research Station, Karjat (Raigad). Studied the performance of F_{1s} along with their parents and three standard checks was done during *kharif* 2016. The higher mean of hybrids for total number of spikelets panicle^{-1} (253.59) was recorded over testers, lines and standard checks 235.19, 244.67, 223.86 respectively. The higher mean of hybrids for number of filled spikelets panicle^{-1} 233.70 over testers (200.77), lines 216.71 and standard checks 192.49 was recorded. The higher mean of hybrids for spikelet fertility 92.16% was recorded over testers, lines and standard checks 85.52%, 88.85% and 85.51, respectively. The higher mean of hybrids for grain yield plant^{-1} 31.92 gram was recorded over testers, lines and standard checks 23.80 gram, 24.20 gram and 30.47 gram. Among the male parents, NPQ-49 recorded higher mean performance for most of the characters and identified as good combiner for some of traits while as among the females, line IR58025B recorded higher mean performance and identified as good combiner for most of the character, could be utilized for further hybridization programme. On the basis of *per se* performance, the hybrids *viz*., IR58025A x NPQ-49 and RTN12A x NPQ-49 was found to be the most promising and may be evaluated critically to judge its superiority in performance and seed production technique for its utility on commercial scale.

Keywords: Rice, lines, testers, hybridization, standard checks and performance

1. Introduction
Rice (*Oryza sativa* L.) is staple food of more than 60% of Indian population. It accounts for about 43% of total food grain production and 46% of total cereal production in the country. Rice occupies pivotal place in Indian Agriculture. India has the largest rice growing area of about 44.1 million hectare, which produced 107.40 million tons of rice during 2016 (Annonymous, 2015-16) [1, 2]. In Maharashtra, rice is the second most important food grain crop of the people grown on an area of 1.55 million hectare with an annual rice production of 3.65 million tones. The average productivity of the Maharashtra state is 2.35 tons per hectare (Annonymous, 2015-16) [1, 2]. Konkan region is a major rice producing area of Maharashtra. Nearly 3.69 lakh hectare area of Konkan is under rice crop with production of 10.83 lakh tones. The average productivity of the Konkan region is 2.93 tons per hectare (Annonymous, 2015-16) [1, 2]. In order to meet the domestic demand of the increasing population the present day production of 107.40 million tons (Annonymous, 2015-16) [1, 2] of milled rice has to be increased to 125 million tons by the year 2030. Since the yield of high yielding varieties (HYVs) of rice is plateauing, it is rather difficult to achieve this target with the present day inbred varieties. Therefore, to sustain the self-sufficiency in rice, additional production of 1.17 million tons is needed every year. Among the limited options, hybrid technology is the only proven technology currently available for stepping up rice production significantly. The rice hybrids introduced in cultivation, on an average, give 10 to 15 quintle per hectare additional yield over the conventional varieties (about 20% increase). Therefore, the development of hybrids and popularization of their production technology are feasible and readily adoptable to achieve targeted production. At present, India has about 2.5 million hectares under hybrid rice cultivation of the total of 44 million hectares under rice cultivation (Ayyappan S. *et al.*, 2012) [3]. The need for hybrid rice rapidly increasing population, plateauing yield trend of HYV's, declining resources. (Viraktamath, B.C., 1997) [11]. Among many genetic approaches being explored to break the yield barrier in rice and increased productivity, hybrid rice technology appears to be the most feasible and readily adaptable one.

2. Materials and Methods
The present investigation was carried out at the Experimental farm of Regional Agriculture Research Station, Karjat (Raigad). Performance of F_{1s} along with their parents and three standard checks was done during *kharif* 2016.

Table 1: List of females, male lines and their hybrids

S. No.	CMS Lines	Restorer Lines	Hybrids
1	IR58025A	Chedo Local	IR58025A x Chedo Local
2	RTN12A	CR-2829-PLN-36	IR58025A x CR-2829-PLN-36
3	RTN17A	NPQ-49	IR58025A x NPQ-49
4		RP-5898-19-8-6-1-1-1	IR58025A x RP-5898-19-8-6-1-1-1
5			RTN12A x Chedo Local
6			RTN12A x CR-2829-PLN-36
7			RTN12A x NPQ-49
8			RTN12A x RP-5898-19-8-6-1-1-1
9			RTN17A x Chedo Local
10			RTN17A x CR-2829-PLN-36
11			RTN17A x NPQ-49
12			RTN17A x RP-5898-19-8-6-1-1-1

Three CMS lines *viz*., IR58025A, RTN 12A and RTN17A were crossed with four testers Chedo Local, CR-2829-PLN-36, NPQ-49 and RP-5898-19-8-6-1-1-1 in a Line × Tester mating design developed 12 hybrids (table 1).

The experiment was laid out in a Randomized Block Design with three replications during *kharif*, 2016 at Regional Agriculture Research Station, Karjat (Raigad). The experimental material consisting of twelve F_{1s}, three CMS lines, four restorers and three standard checks were sown on 21 June 2016. Then twenty-five days old seedlings were transplanted in the main field at 20 x 15 cm spacing with single seedling per hill having plot size 3 x 0.60 m. The recommended fertilizers @ 100 kg N, 50 kg P_2O_5 and 50 kg K_2O along with 7.5 tonnes of FYM per hectare were applied. All standard agronomic recommended practices and plant protection measures were adopted for raising healthy crop. The data for each trait was analyzed by using standard statistical procedure (Panse and Sukthame, 1978) [4].

3. Results and Discussion

The result of quantitative characters are presented below in the table no. 2.

3.1 Performance of parents and their hybrids

Result indicated that, the lines and testers are somewhat similar for days to 50 per cent flowering. While, plant height for lines were recorded shorter than the testers. The lines and testers were showed similar days maturity. More number of productive tillers plant^{-1}, panicle length (cm), straw yield plant^{-1} (g) was recorded in testers. Remaining characters *viz*., total number of spikelets panicle^{-1}, number of filled spikelets panicle-$^{-1}$, spikelet fertility (%), 1000 grain weight (g), grain yield plant^{-1} (g) and harvest index (%) was recorded higher in lines than the testers.

In current investigation, the complex hybrid population was formed by mating three CMS lines and four restorers generating twelve hybrids.

Days to 50 per cent flowering in respect of hybrids showed wide range of variation. It ranged from 93 days (IR58025A x CR2829-PLN-36) to 105 days (RTN17A x Chedo Local).

In respect of plant height of hybrids showed wide range of variation, it ranged from 89 cm (IR58025A x NPQ-49) to 106 cm (RTN12A x Chedo Local). The mean plant height of hybrids was 95 cm. Average plant height of hybrids (95 cm) is similar to overall mean of parents, hybrids and checks (96 cm).

Average days required to maturity in respect of hybrids showed wide range of variation, it ranged from 123 days (IR58025A x CR-2829-PLN-36) to 135 days (RTN17A x Chedo Local). Early maturity increasing yield would be beneficial for commercial use.

The remaining characters *viz*., number of productive tillers plant^{-1}, panicle length (cm), total number of spikelets panicle^{-1}, number of filled spikelets panicle-$^{-1}$, spikelet fertility (%),

Table 2: Mean Performance of parents, hybrids and checks for twelve quantitative characters of rice.

S. No.	Parents / Hybrids / Checks	Days to 50 per cent flowering	Plant height (cm)	No. of productive tillers plant^{-1}	Panicle length (cm)
	CMS Lines				
1	IR58025B	95	88	7.40	21.40
2	RTN12B	96	88	7.60	21.74
3	RTN17B	96	82	7.33	21.37
	Mean	96	86	7.44	21.50
	Testers				
4	Chedo Local	96	113	8.63	21.33
5	CR-2829-PLN-36	95	106	8.33	21.54
6	NPQ-49	95	92	8.00	22.33
7	RP-5898-19-8-6-1-1-1	99	92	7.40	21.33
	Mean	96	101	8.09	21.64
	Hybrids				
8	IR58025A x Chedo Local	103	104	11.00	25.63
9	IR58025A x CR-2829-PLN-36	93	95	11.20	24.40
10	IR58025A x NPQ-49	100	89	12.80	26.00
11	IR58025A x RP-5898-19-8-6-1-1-1	94	90	10.80	22.20
12	RTN12A x Chedo Local	104	106	10.80	26.37
13	RTN12A x CR-2829-PLN-36	95	97	10.90	23.67
14	RTN12A x NPQ-49	101	90	11.97	25.48
15	RTN12A x RP-5898-19-8-6-1-1-1	95	92	11.00	21.53
16	RTN17A x Chedo Local	105	101	10.43	26.10
17	RTN17A x CR-2829-PLN-36	95	96	11.33	23.97

18	RTN17A x NPQ-49	99	90	11.30	25.97
19	RTN17A x RP-5898-19-8-6-1-1-1	102	91	11.20	22.60
	Mean	99	95	11.23	24.49
	Check				
20	Karjat-7 (Variety)	87	93	9.33	21.70
21	Sahyadri-2 (Hybrid)	88	94	11.00	22.06
22	Sahyadri-3 (Hybrid)	95	110	12.00	25.35
	Mean	90	99	10.78	23.04
	Overall Mean	97	96	10.08	23.37

Table 2.

S. No.	Parents / Hybrids / Checks	Total no. of spikelets panicle^{-1}	No. of filled spikelets Panicle^{-1}	Spikelet fertility (%)	1000 Grain Wt. (g)
	CMS Lines				
1	IR58025B	242.33	215.35	89.62	22.13
2	RTN12B	247.68	216.11	87.25	21.20
3	RTN17B	244.00	218.66	89.67	23.70
	Mean	244.67	216.71	88.85	22.34
	Testers				
4	Chedo Local	233.58	196.38	83.96	18.50
5	CR-2829-PLN-36	245.87	199.67	81.41	19.83
6	NPQ-49	213.85	192.04	89.80	19.50
7	RP-5898-19-8-6-1-1-1	247.47	214.98	86.91	20.60
	Mean	235.19	200.77	85.52	19.61
	Hybrids				
8	IR58025A x Chedo Local	261.90	245.75	93.84	22.80
9	IR58025A x CR-2829-PLN-36	261.03	237.30	90.91	25.90
10	IR58025A x NPQ-49	250.00	241.00	96.41	22.47
11	IR58025A x RP-5898-19-8-6-1-1-1	256.37	235.93	92.03	22.63
12	RTN12A x Chedo Local	259.57	241.00	92.88	24.27
13	RTN12A x CR-2829-PLN-36	256.05	235.00	91.83	23.70
14	RTN12A x NPQ-49	249.00	233.00	93.56	21.53
15	RTN12A x RP-5898-19-8-6-1-1-1	252.00	229.94	91.24	21.40
16	RTN17A x Chedo Local	251.00	239.07	95.29	23.77
17	RTN17A x CR-2829-PLN-36	249.00	224.08	89.99	24.23
18	RTN17A x NPQ-49	252.14	229.52	91.04	23.67
19	RTN17A x RP-5898-19-8-6-1-1-1	245.00	212.80	86.84	23.77
	Mean	253.59	233.70	92.16	23.34
	Check				
20	Karjat-7 (Variety)	167.92	136.30	81.29	22.43
21	Sahyadri-2 (Hybrid)	246.67	216.05	87.64	23.90
22	Sahyadri-3 (Hybrid)	257.00	225.13	87.60	26.53
	Mean	223.86	192.49	85.51	24.29
	Overall Mean	248.31	219.78	89.59	22.66

Table 2.

S. No.	Parents / Hybrids / Checks	Grain yield plant^{-1} (g)	Straw yield plant^{-1} (g)	Harvest index (%)	Days to maturity
	CMS Lines				
1	IR58025B	21.80	29.80	42.25	125
2	RTN12B	25.60	32.20	44.28	126
3	RTN17B	25.20	32.60	43.61	126
	Mean	24.20	31.53	43.38	126
	Testers				
4	Chedo Local	24.40	45.20	35.06	126
5	CR-2829-PLN-36	24.20	34.20	41.41	125
6	NPQ-49	24.40	30.20	44.71	124
7	RP-5898-19-8-6-1-1-1	22.20	38.00	36.84	128
	Mean	23.80	36.90	39.50	126
	Hybrids				
8	IR58025A x Chedo Local	33.00	39.80	45.27	133
9	IR58025A x CR-2829-PLN-36	27.40	32.00	46.14	123
10	IR58025A x NPQ-49	39.75	45.20	46.81	130
11	IR58025A x RP-5898-19-8-6-1-1-1	31.80	38.80	45.03	124
12	RTN12A x Chedo Local	32.00	38.47	45.38	134
13	RTN12A x CR-2829-PLN-36	25.44	31.97	44.32	125
14	RTN12A x NPQ-49	38.00	43.19	46.80	131
15	RTN12A x RP-5898-19-8-6-1-1-1	30.67	37.78	44.73	125
16	RTN17A x Chedo Local	31.31	40.15	43.80	135

17	RTN17A x CR-2829-PLN-36	26.00	34.03	43.30	125
18	RTN17A x NPQ-49	37.43	43.52	46.21	129
19	RTN17A x RP-5898-19-8-6-1-1-1	30.27	39.29	43.51	132
	Mean	31.92	38.68	45.11	129
	Check				
20	Karjat-7 (Variety)	25.96	33.11	48.32	117
21	Sahyadri-2 (Hybrid)	29.33	36.57	42.29	118
22	Sahyadri-3 (Hybrid)	36.12	52.00	41.34	128
	Mean	30.47	40.56	43.98	121
	Overall Mean	29.19	37.64	43.70	127

1000 grain weight (g), grain yield plant^{-1} (g) and harvest index (%) higher superior performance were recorded in hybrids over lines, testers and checks Karjat-7, Sahyadri-2 and Sahyadri-3. Hybrids showed considerable improvement in the characters *viz.*, number of productive tillers plant^{-1}, total number of spikelets panicle^{-1}, number of filled spikelets panicle^{-1}, spikelet fertility (%) and grain yield plant^{-1} (g). Many hybrids surpassed the parents for the characters, number of productive tillers plant^{-1}, total number of spikelets panicle^{-1}, number of filled spikelets panicle^{-1}, spikelet fertility (%) and grain yield plant^{-1} (g). The higher mean of hybrids for the character, number of productive tillers plant^{-1} 11.23 was recorded over testers, lines and standard checks 8.09, 7.44 and 10.78 respectively.

The higher mean of hybrids for total number of spikelets panicle^{-1} (253.59) was recorded over testers, lines and standard checks 235.19, 244.67, 223.86, respectively. The higher mean of hybrids for number of filled spikelets panicle^{-1} 233.70 over testers (200.77), lines 216.71 and standard checks 192.49 was recorded. The higher mean of hybrids for spikelet fertility 92.16% was recorded over testers, lines and standard checks 85.52%, 88.85% and 85.51, respectively. The higher mean of hybrids for grain yield plant^{-1} 31.92 gram was recorded over testers, lines and standard checks 23.80 gram, 24.20 gram and 30.47 gram.

Eight hybrids gave higher number of productive tillers plant^{-1}, total number of spikelets panicle^{-1}, number of filled spikelets panicle^{-1}, spikelet fertility (%) and grain yield plant^{-1} (g) over average of parents and standard checks. The three parents *viz.*, IR58025B (female) NPQ-49 and Chedo Local (male) was found to be good for most of the characters and may be extensively used in future hybrid rice breeding programme. These findings are in agreement with those reported by Muhammad *et al.* (2010) [8], Latha *et al.* (2013) [7], Montazeri *et al.* (2014) [9], Islam *et al.* (2015) [5] and Khute *et al.* (2015) [6].

3.2 Analysis of variance of parents and F_{1s}

A study of various sub-divisions of total variance (table no.3) elucidated the importance of variance due to parents and hybrids. The results revealed that the mean squares due to parents for all the characters were found significant except for productive tillers plant^{-1} and panicle length (cm). The mean square values due to males were found to be highly significant for all the traits under study except number of productive tillers plant^{-1} and panicle length (cm). The mean square value due to females were found to be highly significant for all the traits under study except days to 50 per cent flowering, number of productive tillers plant^{-1} and panicle length (cm). The mean square values due to malesvs females were found to be highly significant for all the traits under study except number of productive tillers plant^{-1}, panicle length (cm) and grain yield plant^{-1} (g). The mean square values due to hybrids were found to be highly significant for all the traits under study except number of productive tillers plant^{-1}. This indicated existence of considerable amount of genetic variability among parents and hybrids for all the traits under study. The parents vs. hybrids comparison was found significant for all the characters indicating substantial amount of heterosis in hybrids. Similar results reported by Muhammad *et al.* (2010) [8], Latha *et al.* (2013) [7], Ramlingam and Jebraj (2013) [10], Montazeri *et al.* (2014) [9], Islam *et al.* (2015) [5] and Khute *et al.* (2015) [6].

4. Conclusion

From the present study it was concluded that among the male parents, NPQ-49 recorded higher mean performance for most of the characters and identified as good combiner for some of traits while as among the females, line IR58025B recorded higher mean performance and identified as good combiner for most of the character, could be utilized for further hybridization programme. On the basis of *per se* performance, the hybrids *viz.*, IR58025A x NPQ-49 and RTN12A x NPQ-49 was found to be the most promising and may be evaluated critically to judge its superiority in performance and seed production technique for its utility on commercial scale.

Table 3: Analysis of variance of parents and F_{1s} for twelve characters in rice.

Source of variation	DF	Characters											
		Days to 50 per cent flowering	Plant height (cm)	No. of productive tillers plant^{-1}	Panicle length (cm)	Total no. of spikelets panicle^{-1}	No. of filled spikelets panicle^{-1}	Spikelet fertility (%)	1000 Grain weight (g)	Grain yield plant^{-1} (g)	Straw yield plant^{-1} (g)	Harvest index (%)	Days to maturity
Replication	2	0.018	7.78	1.31	0.36	92.57	49.42	5.14	0.025	0.14	0.36	0.40	0.018
Parents	6	5.38**	370.27**	0.79	0.39	445.97**	370.02**	31.23**	9.15**	6.22**	88.12**	6.60**	5.38**
Males	3	9.33**	326.52**	0.83	0.67	722.92**	298.51**	39.64**	2.27*	3.44	122.2**	57.56**	9.33**
Females	2	1.00	36.00**	0.05	0.12	22.46**	9.00**	5.75**	4.78**	13.09**	6.88**	3.21**	1.01
Males vs Females	1	2.28**	1170.0**	2.15	0.09	462.13**	1306.61**	56.96**	38.5**	0.82	148.1**	77.19**	2.27*
Hybrids	11	54.45**	107.38**	1.15	8.55**	85.67**	234.96**	19.08**	4.74**	63.25**	55.15**	4.48**	54.46**
Parents vs. Hybrids	1	102.92**	7.86**	154.54**	112.6**	2725.1**	9036.16**	359.4**	87.15**	838.3**	221.1**	206.56**	102.91**
Error	36	3.24	18.58	0.71	1.07	87.03	50.65	2.64	0.54	5.17	4.14	6.47	3.25

*Significant at 5% level of significance, **Significant at 1% level of significance

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