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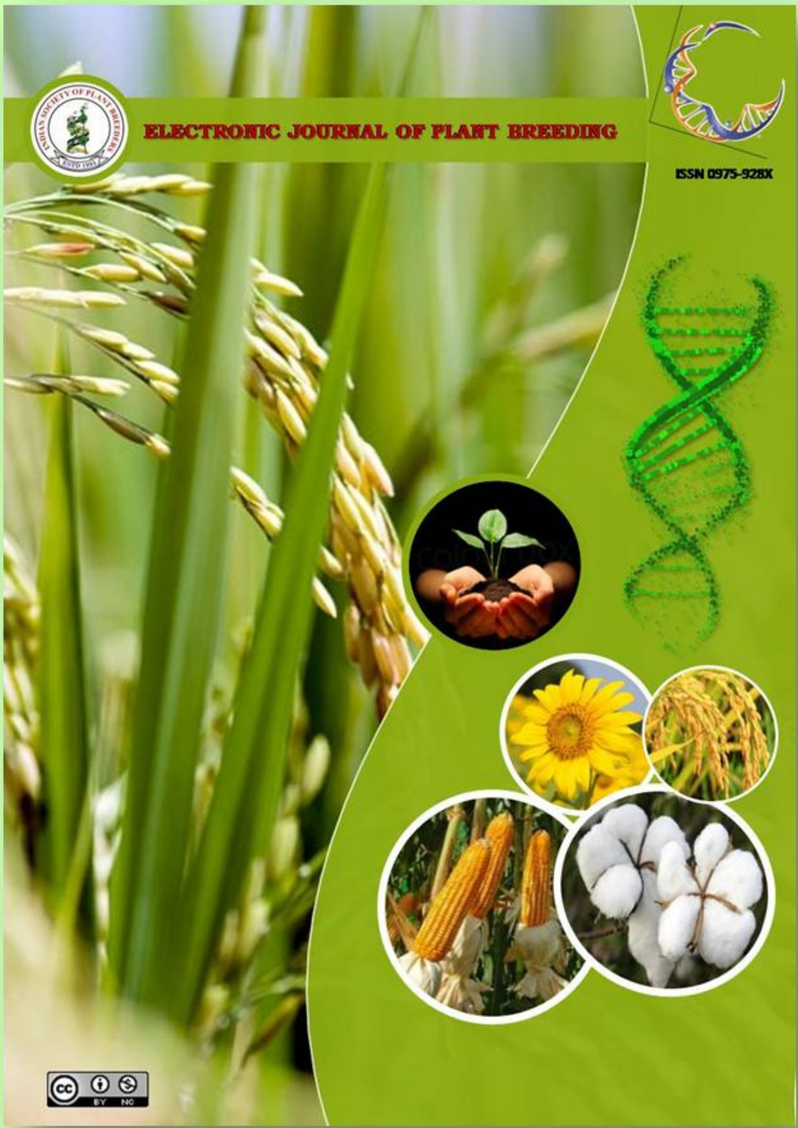

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Research Article

Heterosis and combining ability for yield and yield attributing traits in rice

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Abstract
In the present investigation, combining ability study was undertaken by crossing four rice lines and five testers in Line x Tester fashion. The ratio of GCA and SCA was less than unity for all the characters which revealed the predominance of non additive gene action in the inheritance of these traits. Based on the *gca* effects, four parents *viz.*, MDU 6, ADT (R) 45, IR 64 Drt and CR Dhan 203 were identified as the best combiners for yield and various yield attributing traits. Hence, there is a possibility of getting desirable segregants from the better combining hybrids *viz.*, MDU 6 x IR 64 Drt, ADT (R) 45 x IR 64 Drt and MDU 6 x CR Dhan 203 for yield and yield attributing characters. The cross combinations *viz.*, MDU 6 x CR Dhan 201, MDU 6 x CR Dhan 203, MDU 6 x IR 64 Drt, MDU 6 x GP 239, ADT (R) 45 x IR 64 Drt and ASD 16 x IR 64 Drt with more than 20 per cent standard heterosis for single plant yield were identified as high yielder. Among these, three hybrids MDU 6 x IR 64 Drt, ADT (R) 45 x IR 64 Drt and MDU 6 x CR Dhan 203 had high heterotic performance along with significant *sca* effects.

Keywords
L x T analysis, Combining ability, Standard heterosis, yield traits, Rice.

Introduction

Rice (*Oryza sativa* L.) is the world's most important staple food crop. India is the second largest producer and consumer of rice in the world. Rice is the major source of calorie intake and also contributes to the total agricultural income in most of the Asian countries. Globally rice is cultivated in an area of is 161.1 million ha with an annual production of about 751.9 million tonnes (FAO, 2016). According to Directorate of Economics and Statistics (2016-17), area under rice cultivation in India is 44.2 million ha with 104.32 million tonnes of rice production. The world rice requirement by 2050 will be 943.6 million tones which require an annual increase of 5.8 million tonnes from the present level of production (FAO, 2017). To achieve this target, it is essential to develop varieties with high yield potential.

Breeding strategies for developing hybrids with high yield potential require the expected level of heterosis and high combining ability. Knowledge on combining ability for yield and yield related traits is a prerequisite for the selection of desirable parents for evolving high yielding varieties. Combining ability provides information on the nature and magnitude of gene effects that regulate yield and its contributing traits. Its role is important to decide parents, crosses and appropriate breeding procedures to be followed to select desirable segregants. Combining ability is one of the powerful tools in selecting desirable crosses for the exploitation of heterosis. Positive heterosis is desirable for grain yield and negative heterosis is preferred for earliness and plant height. Standard heterosis is more important in developing superior hybrids over the existing ruling variety (Chaudhary, 1984). Hence, the present study was undertaken with the objective to determine combining ability and heterosis for agronomic traits and grain yield to develop superior high yielding varieties.

Materials and Methods

The present experiment was carried out from 2017 to 2018 in the research farm of Agricultural College and Research Institute, Madurai. The materials for this study comprises of nine parents which includes four high yielding varieties as lines *viz.*,CO 51, MDU 6, ADT (R) 45 and ASD 16 and five drought tolerant lines as testers *viz.*, CR Dhan 201,CR Dhan 203, IR 64 Drt, APO and GP 239. The staggered sowing of the parents was taken to facilitate synchronization in flowering. Crossing block was raised during *Rabi*, 2017.The crossing was effected between the lines and testers in Line x Tester mating design of Kempthorne (1957) to develop hybrids. The good combiners among the parental genotypes and good hybrid combinations

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from the 20 crosses were ascertained using *gca* and *sca* effects (Sprague and Tatum 1942).
The F_1 seeds of 20 cross combinations were planted along with nine parents with a spacing of 20 cm x 20cm in randomized block design with two replications during *Kharif* , 2018.Fertilizer and pesticide applications was done at required time interval. The biometrical observations *viz.*, 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 single plant yield were recorded in each one of the hybrids and parents and the mean performance were tabulated. The standard heterosis was worked with MDU 6 as check variety.

Results and Discussion

Analysis of variances for different characters revealed that the mean square due to lines, testers and lines x testers were highly significant for all the characters (Table 1), revealing that the parents have wide genetic diversity among themselves. The partitioning of combining ability variance into fixable and non fixable indicated both additive and non additive gene action playing a significant role in controlling the expression of all the characters. In the present study, results showed that the ratios of GCA and SCA variances were less than unity for all the characters indicating the predominance of non- additive gene action among the traits. Presence of greater variance of non-additive gene action for all the characters offer scope for exploitation of hybrid vigour through heterosis breeding and selection procedure in late or advanced generation will be very important to improve these traits. Preponderance of non additive variances in the expression of yield attributing traits was also been reported by Sharma *et al.* (2013), Suvathipriya *et al.* (2018) ,Vadivel *et al.* (2018) and Mohanasundram *et al.* (2019).

The effect of general combining ability (*gca*) identifies superior parents, while specific combining ability (*sca*) aids in identification of good hybrid combinations. Regarding *gca* effects, the negative effects for days to 50 % flowering and plant height are considered as desirable, whereas positive effects are desirable for other traits. In the present study, significant general combining ability effect was found in two lines *viz.*, MDU 6 for number of productive tillers per plant, number of grains per panicle, hundred grain weight and single plant yield and ADT (R) 45 for days to fifty per cent flowering, panicle length, number of grains per panicle and single plant yield. Similarly significant *gca* values were registered for various traits by two testers *viz.*, IR 64 Drt for number of productive tillers per plant, panicle length, number of grains per panicle, hundred grain weight and single plant yield and CR Dhan 203 for number of productive tillers per plant, panicle length, number of grains per panicle and single plant yield (Table 2). Hence there is a possibility of selecting desirable progenies and fixing them in the early generations. Good general combiner for yield contributing traits was also reported by Utharasu and Anandakumar (2013), Suvathipriya *et al.* (2018), Vadivel *et al.* (2018) and Kour *et al*. (2019).

The crosses combination MDU 6 x IR 64 Drt had exhibited positive significant *sca* effect values for number of productive tillers per plant, panicle length, hundred grain weight and single plant yield. Another two crosses *viz.*, ADT (R) 45 x IR 64 Drt and MDU 6 x CR Dhan 203 has recorded positive significant *sca* effect for number of productive tillers per plant and single plant yield and negative significant *sca* effect for days to 50 per cent flowering (Table 3). These hybrids are the result of high x high *gca* combiners due to epistatic interactions. These results are in accordance with the earlier findings of Saleem *et al.* (2010), Mirarab *et al.*(2011), Raju *et al.* (2014), Bhatti *et al.*(2015) and Madhuri *et al.* (2017).

Heterosis in rice was first reported by Jones in 1926. A good hybrid manifests high amount of heterosis for commercial exploitation. The hybrid performance is assessed normally in terms of per cent increase over standard parent. Swaminathan *et al.* (1972) indicated the need for computing standard heterosis for commercial exploitation of hybrid vigour. The cross combination MDU 6 x IR 64 Drt has recorded significant positive standard heterosis for number of productive tillers per plant, panicle length, number of grains per panicle and single plant yield. In addition to this three crosses *viz.*, MDU 6 x CR Dhan 203, ADT (R) 45 x IR 64 Drt and ASD 16 x IR 64 Drt also had exhibited significant standard heterosis for following traits *viz.*, number of productive tillers per plant, number of grains per panicle and single plant yield Among the crosses, significant and positive standard heterosis of more than 20 per cent for grain yield was reported in six cross combinations *viz.*, MDU 6 x CR Dhan 201, MDU 6 x CR Dhan 203, MDU 6 x IR 64 Drt, MDU 6 x GP 239, ADT (R) 45 x IR 64 Drt and ASD 16 x IR 64 Drt (Table 4). These results are in agreement with those reported by Utharasu and Anandakumar (2013), Vadivel *et al.* (2018), Kour *et al*. (2019) and Mohanasundram *et al.* (2019) for yield contributing traits.

In the present study, out of nine parents, MDU 6, ADT (R) 45, CR Dhan 203 and IR 64 DRT were adjudged as good general combiners for grain yield and other yield component traits. Based on *sca* effect and high standard heterosis, three crosses *viz.*, MDU 6 x CR Dhan 203, MDU 6 x IR 64 Drt and ADT (R) 45 x IR 64 Drt were identified as best combinations and these can be exploited for heterosis breeding.

References

Bhatti, S., Pandey, D. P., and Singh, D. 2015. Gene action and combining ability studies in rice. *Oryza.*, **51** : 162–164.

Chaudhary, R.C. 1984. *Introduction to Plant Breeding,* New Delhi, Oxford and IBH.

D & ES. 2016. Directorate of Economics & Statistics

FAO. 2016. Food and Agricultural Online Interactive Database on Agriculture. www.fao.org.

FAO. 2017. Food and Agricultural Online Interactive Database on Agriculture. www.fao.org.

Jones, J.W. 1926. Hybrid vigour in rice. *J. American Soc. Agron,* **28**: 423-428.

Kempthorne, O. 1957.An introduction to Genetic statistics, John Wiley and Sons, Inc., New York

Kour, A., Kumar, B., and Singh, B. 2019. Genetic evaluation of yield and yield attributing traits in rice (*Oryza sativa* L.) using line x tester analysis. *Electronic journal of Plant Breeding*, **10** (1), 39-46.

Madhuri, R., Shivakumar, N., Bindhu, K. G., Lohithaswa, H., and Pavan, R. 2017. Gene action and combining ability estimates of newly developed CMS based heterotic rice hybrids (*Oryza sativa* L .). *Jourrnal of Applied and Natural Science.*, **9** : 1557–1565.

Mirarab, M., Ahmadikhah, A. and Pahlavani, M. H. 2011. Study on combining ability, heterosis and genetic parameters of yield traits in rice. *Afr. J. Biotechnol.*, **10** : 12512–12519.

Mohanasundram, K., Rajeshwari, S., Saraswathi, R., and Jeyaprakash, P. 2019. Heterosis and combining ability for yield related traits in rice hybrids involving land races. *Electronic journal of Plant Breeding*, **10** (1), 92-100.

Raju, C. D., Kumar, S. S., Raju, C. H. S. and Srijan, A. 2014. Combining ability Studies in the Selected Parents and Hybrids in Rice (*Oryza sativa*. L). *Int. J. Pure App. Biosci.,* **2** : 271-279.

Saleem, M. Y., Mirza, J. I. and Haq, M. A. 2010. Combining ability analysis for yield and related traits in basmati rice (*Oryza sativa* L .), *Pak. J. Bot.,* **42** : 627–637.

Sharma, R. K. and Mani, S. C. 2013. Analysis of gene action and combining ability for yield and its components in Rice. Oryza, **42**(2): 94-97.

Sprague, G.P. and Tatum, L.A., 1942. General vs specific combining ability in single crosses of corn. *J. American Soc. Agron,* **34** : 923-932.

Suvathipriya, S., and Kalaimagal, T. 2018. Combining ability in rice (Oryza sativa L.) *Electronic Journal of Plant Breeding,* **9** (2): 753-758.

Swaminathan, M.S., Siddiq, E.A., and Sharma, S.D., 1972. Outlook for hybrid rice in India. *In:* Rice breeding. Inter. Rice Res. Inst., Manila, Philippines. pp. 609-613.

Utharasu, S. and C. R. Anandakumar. 2013. Heterosis and combining ability analysis for grain yield and its component traits in aerobic rice (*Oryza sativa* L.) cultivars. Electronic Journal of Plant Breeding ., **4**(4): 1271-1279.

Vadivel, K., Anitha Vasline, Y., and K. R. Saravanan, K.R.2018. Studies on combining ability and heterosis in rice (*Oryza sativa* L.). *Electronic Journal of Plant Breeding,* **9** (3): 1115 – 1121.

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Table 1. Analysis of Variance of combining ability for different quantitative traits in rice

Source of variation	df	**DFF**	**PH**	**NPT**	**PL**	**NGP**	**HGW**	**SPY**
Replications	1	2.50	1.05	1.60	1.15	36.10	0.35	11.24
Crosses	19	60.60**	1833.81**	73.00**	89.11**	1754.40**	19.66**	371.41**
Lines	4	13.00**	293.86**	8.00**	22.46**	4991.80**	55.36**	90.61**
Testers	3	16.85**	1141.10**	41.00**	24.65**	7765.15**	14.45**	180.17**
Lines x Testers	12	30.75**	398.85**	24.00**	42.00**	4722.45**	9.07**	100.63**
Error	19	58.50	336.31	63.40	20.61	988.90	0.67	17.26
GCA		0.02	2.77	0.08	0.03	18.69	0.002	0.49
SCA		0.25	11.12	0.66	1.12	187.69	0.010	3.73
GCA//SCA		0.08	0.24	0.12	0.02	0.09	0.20	0.13

* Significant at 5 per cent level ** Significant at 1 per cent level
DFF – Days to 50% flowering, **PH** – Plant height, **NPT** – Number of productive tillers per plant, **PL** – Panicle length, **NGP** – Number of grains per panicle, **HGW** – Hundred grain weight, **SPY** – Single Plant Yield

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Table 2. General combining ability effects of parents for different quantitative traits in rice

Parents	DFF	PH	NPT	PL	NGP	HGW	SPY
Lines							
ADT (R) 45	-0.7**	3.84**	0.6	0.96**	3.2**	-0.05	0.45*
ASD 16	0.4	0.24	-0.6	0.16	-3.8	-0.04	-0.19
CO 51	-0.4	-3.81**	-0.2	-1.14**	-15.1**	-0.15**	-1.75**
MDU 6	0.7	-0.26	0.2**	0.01	15.7**	0.24**	2.4**
SE	**0.27**	**0.22**	**0.54**	**0.35**	**0.58**	**0.29**	**1.05**
Testers							
APO	0.65	9.48**	-0.63	-1.14**	-9.55**	-0.02	-1.01**
CR Dhan 201	0.15	-0.21	-0.63	-0.08	4.32	-0.04	-0.19
CR Dhan 203	0.03	-2.46	0.25*	0.99*	6.32*	0.01	0.7**
GP 239	-1.23	-6.84**	-0.88	-0.51	-20.8**	-0.09**	-2.14**
IR 64 Drt	0.4	0.04	1.88**	0.74*	19.7**	0.14**	4.05**
SE	**0.24**	**0.20**	**0.48**	**0.31**	**0.52**	**0.26**	**0.94**

* Significant at 5 per cent level ** Significant at 1 per cent level
DFF – Days to 50% flowering, **PH** – Plant height, **NPT** – Number of productive tillers per plant, **PL** – Panicle length, **NGP** – Number of grains per panicle, **HGW** – Hundred grain weight, **SPY** – Single Plant Yield

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Table 3. Specific combining ability effects of hybrids for different quantitative traits in rice

Crosses	DFF	PH	NPT	PL	NGP	HGW	SPY
ADT (R)45 x CR Dhan 201	0.95	-0.09	-1.48	0.73	14.18*	0	0.44
ADT (R) 45 x CR Dhan 203	0.57	2.66	0.15**	0.66	-1.82	0.05	-1.05
ADT (R) 45 x IR 64 Drt	-1.8	-0.34**	0.02**	-0.34	8.8	-0.08	2.2**
ADT (R) 45 x APO	-0.55	1.22	1.52	0.79	-13.45*	-0.02	-0.74
ADT (R) x GP 239	0.82	-3.46	-0.23	-1.84*	-7.7	0.05	-0.86
ASD 16 x CR Dhan 201	-0.65	3.51	0.23	-0.47	-16.33**	-0.11	-2.02**
ASD 16 x CR Dhan 203	0.47	0.76	-0.65	0.71	5.68	0.04	-1.06
ASD 16 x IR 64 Drt	1.1	1.26	0.23	-0.29	9.8	-0.13*	1.19
ASD 16 x APO	-0.15	-7.18*	0.23	-0.66	3.05	0.16**	1.75*
ASD 16 x GP 239	-0.77	1.64	-0.02	0.71	-2.2	0.04	0.13
CO 51 x CR Dhan 201	0.65	2.81	1.83	-0.92	-4.02	0	0.99
CO 51 x CR Dhan 203	-0.73	-0.19	0.45	-0.74	-1.02	-0.05	2.5*
CO 51 x IR 64 Drt	-1.1	-1.19	-0.68	-0.99	-25.9**	0.02	-4.25**
CO 51 x APO	0.65	-0.63	-1.17	1.89*	21.35**	-0.02	1.07
CO 51 x GP 239	0.53	-0.81	-0.43	0.76	9.6	0.05	-0.31
MDU 6 x CR Dhan 201	-0.95	-6.24*	-0.57	0.68	6.18	0.11	0.59
MDU 6 x CR Dhan 203	-0.32	-3.24**	0.05*	-0.64	-2.82	-0.04	0.4**
MDU 6 x IR 64 Drt	1.8	0.26	0.43**	1.61*	7.3	0.19**	0.85**
MDU 6 x APO	0.05	6.57*	-0.57	-2.01*	-10.95*	-0.12*	-2.09**
MDU 6 x GP 239	-0.57	2.64	0.68	0.36	0.3	-0.14*	1.04
SE	**0.54**	**0.45**	**1.08**	**0.69**	**2.08**	**0.58**	**2.09**

* Significant at 5 per cent level ** Significant at 1 per cent level

DFF – Days to 50% flowering, **PH** – Plant height, **NPT** – Number of productive tillers per plant, **PL** – Panicle length, **NGP** – Number of grains per panicle, **HGW** – Hundred grain weight, **SPY** – Single Plant Yield

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Table 4. Estimates of per cent standard heterosis for seven quantitative traits in rice

Crosses	DFF	PH	NPT	PL	NGP	HGW	SPY
ADT (R)45 x CR Dhan 201	-4.55	20.59**	21.05*	11.96*	20.86**	-21.43**	16.38**
ADT (R) 45 x CR Dhan 203	-5.19*	21.08**	34.21**	16.3**	12.86**	-16.67**	9.48**
ADT (R) 45 x IR 64 Drt	-7.79**	20.59**	42.11**	10.87*	26.57**	-16.67**	37.07**
ADT (R) 45 x APO	-5.84*	31.37**	36.84**	7.61	-2.86	-21.43**	9.48**
ADT (R) x GP 239	-6.49**	10.78*	26.32**	-1.09	-6	-21.43**	5.17
ASD 16 x CR Dhan 201	-5.19*	20.59**	23.68*	3.26	-0.57	-26.19**	8.79*
ASD 16 x CR Dhan 203	-3.9	15.69**	23.68*	13.04**	13.14**	-16.67**	10.34**
ASD 16 x IR 64 Drt	-2.6	18.63**	36.84**	7.61	23.14**	-19.05**	34.48**
ASD 16 x APO	-3.9	19.61**	23.68*	-2.17	2.57	-11.9**	18.97**
ASD 16 x GP 239	-7.14**	12.25**	21.05*	6.52	-6.86	-21.43**	9.48**
CO 51 x CR Dhan 201	-4.55	15.93**	34.21**	-4.35	0	-26.19**	13.79**
CO 51 x CR Dhan 203	-6.49**	10.78*	31.58**	1.09	2.86	-26.19**	17.24**
CO 51 x IR 64 Drt	-6.49**	12.25**	34.21**	-1.09	-3.71	-16.67**	10.34**
CO 51 x APO	-3.9	22.06**	18.42	3.26	6.57	-26.19**	11.21**
CO 51 x GP 239	-6.49**	5.88	21.05*	1.09	-6.57	-26.19**	2.59
MDU 6 x CR Dhan 201	-5.19*	10.54*	23.68*	7.61	23.43**	-2.38	26.72**
MDU 6 x CR Dhan 203	-4.55	11.27*	31.58**	6.52	19.43**	-7.14	21.55**
MDU 6 x IR 64 Drt	-1.3	17.16**	42.11**	15.22**	32.86**	9.52*	42.24**
MDU 6 x APO	-3.25	32.6**	23.68*	-8.7	5.71	-11.9**	14.66**
MDU 6 x GP 239	-6.49**	12.75**	28.95**	4.35	5.71	-16.67**	21.55**

* Significant at 5 per cent level ** Significant at 1 per cent level
DFF – Days to 50% flowering, **PH** – Plant height, **NPT** – Number of productive tillers per plant, **PL** – Panicle length, **NGP** – Number of grains per panicle, **HGW** – Hundred grain weight, **SPY** – Single Plant Yield

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