STUDY OF NATURE AND MAGNITUDE OF GENE ACTION IN HYBRID RICE (*Oryza sativa* L.) THROUGH LINE X TESTER MATING DESIGN

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Abstract: *An experiment of line x tester mating design was conducted to study the nature and magnitude of gene action i.e. general combining ability (GCA) and specific combining ability (SCA) of 12 yield and yield contributing characters. The experiment was conducted with 7 rice genotypes and 12 F_{1s} at the experimental field of RARS, Karjat during rabi 2015 to kharif 2016. Highly significant differences for genotypes and lines were observed which revealed the wide range of variability among the genotypes and lines studied. The GCA variances were found significant for most of the characters. Higher ratio of SCA and GCA variances indicating preponderance of non-additive gene actions in the inheritance of all the characters except days to 50 per cent flowering, number of filled spikelets panicle^{-1} and days to maturity results revealed the higher estimates of GCA variances i. e. additive gene action but in case of plant height, number of productive tillers plant^{1}, panicle length, total number of spikelets panicle^{-1}, spikelet fertility, 1000 grain weight, grain yield per plant, straw yield plant^{1} and harvest index higher estimates of SCA variance i.e. non-additive gene action were found. Among the male parents, NPQ-49 and Chedo Local were observed to be good general combiner for most of the character studied. Cross combinations, IR58025A x NPQ-49 and RTN12 A x NPQ-49 were observed to be good specific cross combinations for magnitude of gene action.*

Key words: *Rice, additive gene action, non-additive gene action, GCA, SCA and yield.*

Introduction

Success of any plant breeding program depends on the choice of appropriate genotypes as parents in the hybridization program. The combining ability studies of the parents provide information which helps in the selection of better parents for effective breeding. Rice 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. In order to meet the domestic demand of the increasing population the present day production of 107.40 million tons (Annonymous, 2015-16) 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. Hybrid rice offers an opportunity to boost the yield potential of rice. It has a yield advantage of 15-20% over conventional high yielding variety. The breeding of yield rich and quantitatively better rice varieties is not possible without prior knowledge of their genetic properties. The breeders therefore try, with the help of suitable quantitatively genetic method to combine the desired properties of different varieties. Combining ability analysis is one of the powerful tools available to estimate the combining ability effects and aids in selecting the desirable parent and crosses for the exploration of heterosis. There is a bright scope to study the combining ability that is prerequisite for developing hybrid rice varieties with good quality in India. Combining ability is a powerful tool in identifying the best combiners that may be used in crosses either to exploit heterosis or to accumulate fixable genes and obtain desirable segregates. It will help to understand the genetic architecture of various characters that enable the breeder to design effective breeding plan for future up gradation of the existing materials. This information may also be useful to breeders for genetic improvement of the existing genotypes on the basis of the performance in various hybrid combinations. The line x tester analysis in rice is used principally to determine the general and specific combining ability of the quantitative properties. Exploitation of hybrid vigor, development of new plant type, introgression of foreign genes related to biotic and abiotic stresses may be some of the alternatives to have a breakthrough in this regard. Improvement of rice variety through the above techniques requires perfect knowledge of genetic background of the economic traits in rice plant. Therefore, an attempt has been undertaken to investigate the genetic behavior of different agronomic traits in rice. Therefore, hybridization programme made at Regional Agriculture Research Station, Karjat. Dist. Raigad. (MS) to estimate the nature and magnitude of gene action studies for different yield and yield contributing traits in rice.

Materials and Methods

The experiment was conducted at the Experimental farm of Regional Agriculture Research Station, Karjat (Raigad). The identified parents were growing during December, 2015 and the crossing programme was under taken during April, 2016 and evaluation of F_{1s} along with parents and three standard checks was done during *kharif* 2016. 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. 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 alongwith 7.5 tonnes of FYM per hectare were applied. All standard agronomic recommended practices and plant protection measures were adopted for raising healthy crop. Five sample plants were randomly selected from each plot excluding the border plants and the following data were recorded: Plant height, days to 50% flowering, number of productive tillers plant^{-1}, panicle length, total spikelet panicle^{-1}, filled spikelet panicle^{-1}, spikelet fertility, grain yield plant, straw yield plant, harvest index, 1000 grain weight and days to maturity. Standardized values were calculated as suggested by Johnson and Askel (1959). The interpretations was made as per Dhabolkar (1992), Sharma (1998) and Mather and Jinks (1949).

Result and Discussion

The analysis of variance revealed significant genotypic effect for all the charactres under study for parents except for productive tillers plant^{-1} and panicle length. This provides evidence for the presence of sufficient genetic variability among lines, testers and test crosses indicating wide diversity among treatment themselves. (Table 1.). Significance mean sum squares of females and males indicated prevalence of additive variance whereas, non additive variance by line x tester. Variance due to interaction effect of male and female were found to be highly significant for all the traits under study except number of productive tillers plant^{-1}, panicle length and grain yield plant^{-1}. The mean square 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 Sanghera *et al.* (2012), Latha *et al.* (2013), Islam *et al.* (2015) and Khute *et al.* (2015).

The nature of gene action could be helpful in predicts the effectiveness of selection in population. The progress in indirect selection would be possible if the gene action involved is primarily of additive type on the other hand, direct selection would be ineffective if non-additive type gene action is predominant in the population. In current investigation, the characters recorded ratio (σ^2A/σ^2D) less than one, which presents non-adctitive gene action while one or greater than one which present additive gene action. Suggesting, such characters can be improved upon through heterotic breeding.

A high general combining ability denotes, that the character is under the control of additive genes and high specific combining ability denotes that the character is under the control of non-additive gene action. The magnitude of variance due to general combining ability, specific combining ability and dominant components (Table 2).

The highest σ^2g was estimated for the character total number of filled spikelets panicle^{-1} (40.19) followed by plant height (18.05), grain yield plant^{-1} (11.14), total spikelets panicle^{-1} (10.59), straw yield plant^{-1} (9.40), days to 50 per cent flowering (7.06) and days to maturity (7.05).

The lowest σ^2g estimates were observed for spikelet fertility (1.56) followed by panicle length (1.41), harvest index (0.73), 1000 grain weight (0.30) and number of productive tillers plant^{-1} (0.10).

In case of σ^2s, the highest estimate was recorded for the characters number of filled spikelets panicle^{-1} (7.38) followed by days to maturity (3.58), days to fifty percent flowering (3.54), spikelet fertility (3.10) and 1000 grain weight (0.83).

The lowest estimates of σ^2s were recorded plant height (-6.40) followed by total number spikelets panicle^{-1} (-2.67), grain yield plant^{-1} (-1.73), harvest index (-1.54), straw yield plant^{-1} (-0.75), panicle length (-0.12) and number of productive tillers plant^{-1} (-0.34). If the ratio of σ^2A and σ^2D was greater than one indicates the additive gene action, while, less than one indicates non-additive gene action. The characters viz., number of filled spikelets panicle^{-1} (5.45), days to 50 per cent flowering (1.99) and days to maturity (1.96) were indicates that these characters were under the control of additive gene action and remaining characters plant height (-2.82), number ofproductive tillers plant^{-1} (-1.43), panicle length (-11.75), total number of spikelets panicle^{-1} (-3.97), spikelet fertility (0.50), 1000 grain weight (0.36), grain yield plant^{-1} (-6.44), straw yield plant^{-1} (-12.53) and harvest index (-0.47) were under the control of non-additive gene action.

The characters, *viz*., days to 50 per cent flowering, number of filled spikelets panicle^{-1} and days to maturity showed additive gene action and remaining characters *viz*., plant height (cm), number of productive tillers plant^{-1}, panicle length (cm), total number of spikelets panicle^{-1}, spikelets fertility (%),1000 grain weight, grain yield plant^{-1}, straw yield plant^{-1} and harvest index (%) were under the control of non-additive gene action reported by Chakraborty et al. (1994), Virmani (1996), Ganesan *et al.* (1997), Annadurai and Nadarajan (2001), Sharma *et al.* (2013), Prajapati and Mistry (2014) and Rahaman (2016) were reported both additive and non-additive gene action for all the characters.

Conclusion

From the present study it was concluded that The traits viz., number of filled spikelets panicle^{-1}, days to 50 per cent flowering and days to maturity were indicates that these characters were under the control of additive gene action and remaining all traits viz., plant height (cm), number of productive tillers plant^{-1}, panicle length (cm), total number of spikelets panicle^{-1}, spikelet fertility (%), 1000 grain weight (g), grain yield plant^{-1} (g), straw yield plant^{-1} (g) and harvest index (%) were under the control of non-additive gene action.

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Table 1: Analysis of variance in Line x Tester analysis 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**	88.1**	6.60**	5.38**
Male	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**
Female	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
Male vs Female	1	2.28**	1170**	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**
Line effect	2	22.75**	11.86**	0.475	0.510	196.82**	566.75**	19.33**	3.95**	10.42**	4.49**	8.08**	22.7**
Tester effect	3	155.00**	376.48**	2.77**	30.08**	104.21**	380.48**	35.24**	8.55**	224.29**	194.36**	9.21**	155.00**
Line vs. Tester effect	6	14.75**	4.67**	0.578	0.479	39.34**	51.59**	10.92**	3.10**	0.353	1.77	0.915	14.7**
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

*p< 0.05, **p< 0.01

Table 2: Estimation of gene action for twelve characters in rice

Sr. No.	Genetic parameters / Chracters Characters	σ^2GCA	σ^2SCA	σ^2GCA/ σ^2SCA
1	Days to 50 per cent flowering	7.06	3.54	1.99
2	Plant height (cm)	18.05	-6.40	-2.82
3	Number of productive tillers plant^{-1}	0.100	-0.07	-1.43
4	Panicle length (cm)	1.41	-0.12	-11.75
5	Total number of spikelets panicle^{-1}	10.59	-2.67	-3.97
6	Number of filled spikelets panicle^{-1}	40.19	7.38	5.45
7	Spikelet fertility (%)	1.56	3.10	0.50
8	1000 grain weight (g)	0.30	0.83	0.36
9	Grain yield plant^{-1} (g)	11.14	-1.73	-6.44
10	Straw yield plant^{-1} (g)	9.40	-0.75	-12.53
11	Harvest index (%)	0.73	-1.54	-0.47
12	Days to maturity	7.05	3.58	1.96