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Analysis of combining ability in short duration rice genotypes (*Oryza sativa* L.)

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Abstract

Combining ability analysis of the parentage to be utilized in breeding programme is essential for substantial maximization of the genetic gain and selection of efficient breeding methodology. Altogether, 28 F_1's generated in diallele fashion (excluding reciprocals) along with parents were evaluated and analysed for combining ability of yield and 13 contributing traits. In the study, most of the yield components were governed by both additive and non-additive gene effects with dominated non-additive gene action. The additive gene action (GCA) was found substantial for 1000-grain weight. The parental genotype NDR 97 and Vandana were found good general combiners. The hybrids namely Vandana/Hazaridhan, Vandana/ Sahabhagidhan, Vandana/ Kamesh, Vandana/ Virendra, Vandana/ Sahabhagidhan, Vandana/ NDR 97, Vandana/ Shusk Samrat, Hazaridhan/ Kamesh, Hazaridhan/Virendra, Sahabhagidhan/ Virendra, Sahabhagidhan/ NDR 97, Kamesh/ Narendra-80, Kamesh/ NDR 97, Kamesh/ Shusk Samrat, Virendra/ Narendra-80, Narendra-80/ NDR 97 and NDR 97/Shusk samrat have shown significant favourable *sca* effect for yield and different yield components

Keywords: Combining ability, GCA effect, sca effect, short duration rice, transgressive segregants

1. Introduction

Rice (*Oryza sativa* L.) is a staple food crop of global significance used as a primary food by more than half of the world's population (Singh *et al.*, 2013). It is a premier crop, in terms of its calorie contribution to human diet and monetary value of food production in developing world (Sasaki, 2005; Singh *et al.*, 2014). Globally, it occupies more than 146 million ha land which produces approximately 685 million tonnes of grain annually (RMM-USDA, 2014). It has great role in alleviating poverty and malnutrition, and reaffirming the need to focus world attention on its role in providing food security and eradicating poverty, especially in developing countries (IRRI, 2014). In India, it occupies about 44 million ha of cultivated area (~22% of total cropped area) of rice with an annual production of 106.54 million tonnes which contributes approximately to 25% in agricultural GDP.

India has vast rain fed upland area, in view of increasing water scarcity and short duration high yielding rice varieties are need of the hour. The cultivation of short duration rice is very economical for farmers, but owing to very poor in yield potential and sustainability under extreme condition needs attention. In order to formulate efficient breeding strategies for improvement of yield, it is essential to characterise the nature and mode of gene action that determines the yield and its components. A sound breeding methodology rests on a proper understanding of the gene effects involved (Kumar *et al.* 2012) [1].

The combining ability studies of the parents and their crosses provide information for the selection of high order parents for effective breeding. Success of any plant breeding programme depends on the choice of right type of genotypes as parents in the hybridization programme. Combining ability analysis provides information on two components of variance viz., additive and dominance variance. Its role is important to decide parents, crosses and adoption of appropriate breeding procedures to be followed to select desirable segregants (Salgotra *et al*. 2009) [12]. Therefore, the present investigation was undertaken to select right type of short duration varieties as parents in the hybridization programme and the appropriate breeding procedures to be followed involving indigenous and exotic promising short duration rice varieties.

Materials and methods

The investigation comprised 8 short duration rice varieties namely Vandana, Hazaridhan, Sahabhagidhan, Kamesh, Virendra, Narendra-80, NDR 97 and Shusk Samrat which were crossed in half diallele fashion during Kharif 2016. The crosses along with parental lines (28 crosses and 8 parents) were evaluated under randomised block design with two replications at research farm of Institute of Agricultural Science, BHU, Varanasi. Experiment was transplanted with 20 cm x 15 cm, solitary seedling/hill and grown under recommended agronomical practice and packages. Observations were taken from five randomly selected competitive plants by excluding border rows (Dhaliwal and Sharma, 1990) [3]. Observations were recorded on 14 characters *viz*., days to 50% flowering (DF), plant height (PH), flag leaf length (FL), flag leaf breadth (FB), panicle length (PL), number of panicles plant^{-1} (PN), grain number panicle^{-1} (GP), 1000-grain weight (TW), grain yield plant^{-1} (GY), kernel length (KL), kernel breadth (KB), kernel L/B ratio (LBR), amylose content (AC) and alkali spreading value (AS). The combining ability analysis was assessed utilizing as per Griffing (1956), Method-2.

Table: rice genotypes utilized in this investigation

Genotype/variety	Parent institute	Important features
Vandana	CRURRSH, Hazaribag	Early duration, tolerant to drought, acidic soil and suitable for late sowing
Hazaridhan	CRURRSH, Hazaribag	Early duration, tolerant to drought at vegetative stage
Sahabhagidhan	CRURRSH, Hazaribag	Early duration, tolerant to drought
Kamesh	CRURRSH, Hazaribag	Early duration, suitable for upland
Virendra	CRURRSH, Hazaribag	Early duration, tolerant to drought
Narendra-80	NDUA&T, Kumarganj	Early duration, drought tolerant
NDR 97	NDUA&T, Kumarganj	Early duration, drought tolerant
Shusk Samrat	NDUA&T, Kumarganj	Early duration, drought tolerant

Results and Discussion

Genetic compatibility among parents is key to success the any breeding programme. Rice which is an important dietary component of Asians is needs to be further invigorated for their productivity and production. Development of climate smart short duration variety is very crucial to sustain this crop under current transitional climatic scenario. Keeping in the views, we analysed combining ability of 8 short duration rice varieties. ANOVA for combining ability revealed that (Table 1) the variances due to general combining ability (GCA) was highly significant for all characters except KB. Besides, variances due to specific combining ability (*sca*) were also significant for all the studied characters. This indicates that the variances in the population were conditioned by additive as well as non-additive genic effects. The greater magnitude of GCA variances over *sca* variances for the traits DF, FB, GP, TW, GY, HI, KL, LBR, AC and AS, which are known to be major yield contributor in rice indicate the prevalence of additive genetic variances which is good indicator of success of transgressive breeding. However, rest of the characters investigated has greater degree of *sca* variance indicating prevalence of dominance gene action involved in the inheritance of these traits which also good sign for invigoration of heterosis breeding programme. Hence, parental lines involved in the study are more suitable increasing the breeding value through transgressive approach for upland ecosystem.

The analysis of *sca* effect and GCA*: sca* ratio (Table 2) revealed that almost all studied characters except TW are substantially conditioned by non-additive gene effect. Though variances for GCA (additive genetic variance) were found to be substantial and the dominant component was also preponderant for all the characters except for TW.

Occurrence of both additive and non-additive gene effects with preponderance of non-additive gene action for yield and important yield components in rice were reported by several scientists like Peng and Virmani (1990) [10], Manuel and Prasad (1992) [9], Sharma *et al*. (1996) [13], Ganesan *et al*. (1997) [4] and Vanaja *et al*. (2003) [16].

Analysis of general combining ability effects

General combining ability in plant is conditioned by additive genetic variances, hence it very important in maximization of genetic gain in rice. Under this investigation, the genotype NDR 97 was found to be a good general combiner for days to fifty percent flowering, plant height, flag leaf length, panicle length, grain per panicle, grain yield per plant, kernel length, kernel breadth and amylose content (Table 3). Besides, other general combiners for different characters were Vandana for plant height, flag leaf width, grain per panicle, grain yield per plant; Hazaridhan was found good general combiner for the traits panicle number; Kamesh for days to flowering, plant height, flag leaf width, panicle length, grain per panicle, grain yield, kernel length, amylose content and alkaline spreading value; Virendra for panicle number, grain per panicle, grain yield, and amylose content; Narendra-80 for plant height and test weight; and Shusk Samrat was found to be general combiner for days to flowering, plant height, flag leaf length, grain per panicle, kernel length, grain length breadth ratio and amylose content.

Analysis of specific combining ability

Specific combining ability in plants is governed by dominant gene variances which is prerequisite for exploitation of heterosis. Under the investigation, 17 F_1's namely C-1, C-2, C-4, C-5, C-6, C-7, C-9, C-10, C-15, C-17, C-20, C-21, C-22, C-23, C-26 and C-28 exhibited significant *sca* effects for GY (Table 4) indicate good sign for occurrence of rare transgressive segregants from these crosses. All crosses involved at least one parentage having positive general combining ability effects (GCA) suggested superior crosses to be advanced for selection/pedigree breeding. Besides, 7 crosses involved both parent with positive GCA effect (Table 3) are also very important for transgressive breeding. The hybrid C-23 showed significant favourable *sca* effects for eight yield components (Table 4). The hybrids C-6, C-5 and C-21 showed significant favourable *sca* effects for seven yield contributing traits; C-3, C-5, C-10, C-15, C-17, C-25 and C-28 were shown significant *sca* effects for six yield components; C-12, C-1, C-7 and C-22 were found with significant *sca* effect for five yield components.

The crosses C-3, C-4, C-6, C-7, C-21, C-22 and C-28 for GY shown high *sca* effects which are also in the category of high x high general combiner cross combinations. This is attributable to additive and/or additive x additive type of gene effects which are fixable in nature (Singh *et al.*, 1971) [14]. Therefore, there is high probability of obtaining good transgressive segregants in the progeny of these crosses for improvement of respective trait. On the other hand, C-1 and C-2 both of which displayed high *sca* effects for GY had common female parent with significant GCA while male parent with non-significant GCA respectively. The case of high *sca* between high x poor combiners could produce good segregants only if the additive genetic effects are present in the good general combiners and complimentary epistatic effects in the poor combiners and they act in the same direction to maximise desirable plant attributes (Singh and Chaudhary, 1992).

The non-significant *sca* effect was exhibited by the cross C-19 for GY. These according to Devraj and Nadarajan (1996) [2] are expected to produce desirable recombinants in advance generation of inbreeding. The cross C-8 showed high *sca* effect for DF and PH while parents were poor x poor general combiners. This is belived to be due to epistatic gene action. In other hybrids also, all kinds of parental combinations like high x high, high x low, medium x medium and medium x low were found. These type of interactions, according to Dhaliwal and Sharma (1990) [3], Katre and Jambhale (1996) [8], Ramalingam *et al.* (1997) [11] and Vanaja *et al.* (2003) [16] attributed to either additive x additive and/or additive x dominance genetic interactions. Also they suggested that the superiority of these crosses may be due to complimentary and duplicate type of gene interactions. Therefore, these crosses are expected to produce desirable segregants and could be exploited successfully in varietal improvement programme.

The present study reveals importance of both additive and non-additive gene effects in governing yield and yield attributes with preponderance of non-additive gene action. In this situation, where both non-additive and additive components were important for the expression of characters, especially when the former component is preponderant, simple pedigree method of selection would be ineffective for its improvement. Population improvement programme like reciprocal recurrent selection which may allow to accumulate the fixable gene effects as well as to maintain considerable variability and heterozygosity for exploiting non-fixable gene effects will prove to be the most effective method (Joshi, 1979) [7]. However rice is the highly self pollinated crop, forming single seed per pollination, this selection procedure not practicable. Three of the top parents, F_1's, general combiners and specific combiners for various characters based on *per se* performance of parents and F_1's.

Table 1: Values of general combining ability (GCA) variances and specific combining ability (*sca*) variances for different characters

S. No.	Source of Variation	d.f.	Mean sum of squares													
			DF	PH (cm)	FL (cm)	FB (cm)	PL (cm)	PN	GP	TW (g)	GY (g)	KL (mm)	KB (mm)	LBR (mm)	AC	AS
1.	GCA	7	98.32**	1008.24**	43.05**	0.12**	5.98**	14.08**	136.52**	11.29**	217.61**	0.545**	0.017	0.281**	2.473**	0.388**
2.	SCA	28	34.91**	227.12**	34.60**	0.029**	4.05**	35.87**	85.347**	4.119*	203.372**	0.338**	0.022**	0.238**	0.582**	0.268**
3.	Error	105	6.348	29.28	10.89	0.027	1.280	2.512	25.862	1.982	0.801	0.051	0.023	0.112	0.185	0.098
4.	GCA/SCA		2.98	4.125	1.24	1.54	1.10	0.198	3.04	3.54	1.25	2.31	0.80	1.65	2.68	1.86

* and ** Significant at 5 and 1 per cent probability levels, respectively

Table 2: Estimates of components of genetic variance from 8 x 8 half diallel analysis using Griffing's Method-2

Components of genetic variance	DF	PH (cm)	FL (cm)	FB (cm)	PL (cm)	PN	GP	TW (g)	GY (g)	KL (mm)	KB (mm)	LBR (mm)	AC	AS
Additive genetic variance	15.32	148.36	0.34	0.002	0.22	6.28	144.16	1.87	18.08	0.03	0.0016	0.022	0.18	0.06
Non-additive genetic variance	22.35	254.25	11.65	0.014	2.30	45.24	542.45	1.53	178.57	0.12	0.005	0.053	0.39	0.068
Variance due to error	4.985	22.65	10.52	0.008	0.707	1.98	34.430	2.148	0.658	0.065	0.008	0.044	0.125	0.050
Ratio of additive to non-additive genetic variance	1.24	0.46	0.021	0.056	0.06	0.210	0.38	1.24	0.09	0.15	0.066	0.24	0.56	0.40

DF- Days to 50 % flowering, PH- Plant height, FL- Flag leaf length, FB- Flag leaf breadth, PL- Panicle length, PN- Number of panicles plant^{-1}, GP- Grain number panicle^{-1}, TW- 1000 grain weight, GY- Grain yield plant^{-1}, KL- Kernel length, KB- Kernel breadth, LBR- Kernel L/B ratio, AC- Amylose content and AS- Alkali spreading value.

Table 3: Values of general combining ability (GCA) effect of parents for various characters

S. No.		DF	PH (cm)	FL (cm)	FB (cm)	PL (cm)	PN	GP	TW (g)	GY (g)	KL (mm)	KB (mm)	LBR (mm)	AC	AS
1	Vandana	-0.825	-3.83*	1.28	0.080**	-0.089	-0.077	12.64**	0.725	7.28**	0.06	-0.022	0.074	-0.22	-0.07
2	Hazaridhan	4.47**	18.18**	-1.24	-0.034	-0.356	1.558**	-20.45**	-0.58	-7.84**	-0.13	0.034	-0.124*	0.15	-0.15*
3	Sahabhagidhan	5.225**	12.148**	-1.248	-0.032	-0.510	-1.872**	-9.194**	-.917*	-6.59**	-0.39**	0.021	-0.259**	-0.24	-0.22**
4	Kamesh	-2.425**	-4.233*	-0.895	0.052*	0.532*	-0.862*	5.498**	0.24	1.36**	0.188*	0.004	0.12	0.42**	0.24**
5	Virendra	0.026	2.488*	-0.865	-0.034	0.448	0.968*	4.264*	-1.55**	1.58**	0.02	-0.002	0.012	0.15	0.20*
6	Narendra-80	0.248	-5.322**	-0.758	-0.062*	-0.521*	-0.651	-7.135**	2.31**	-2.12**	-0.08	-0.05*	0.056	0.13	-0.04
7	NDR 97	-1.624*	-5.023**	1.854*	-0.012	0.785*	0.366	12.66**	-0.123	4.58**	0.145*	0.048*	0.008	0.22*	-0.13
8	Shusk Samrat	-4.245**	-12.42**	2.26*	0.042	-0.230	-0.049	3.230*	-0.166	1.68**	0.152*	-0.026	0.161*	-0.77**	0.25*
	SE (gi)	0.615	1.42	0.94	0.03	0.28	0.47	1.83	0.48	0.36	0.042	0.021	0.08	0.14	0.09
	S E (gi-gj)	1.24	1.98	1.24	0.02	0.5	0.60	2.48	0.76	0.44	0.18	0.04	0.12	0.18	0.14

* and ** Significant at 5 and 1 per cent probability levels, respectively DF- Days to 50 % flowering, PH- Plant height, FL- Flag leaf length, FB- Flag leaf breadth, PL- Panicle length, PN- Number of panicles plant^{-1}, GP- Grain number panicle^{-1}, TW- 1000 grain weight, GY- Grain yield plant^{-1}, KL- Kernel length, KB- Kernel breadth, LBR- Kernel L/B ratio, AC- Amylose content and AS- Alkali spreading value.

Table 4: values of specific combining ability (*sca*) effect for different characters

S. No.	Crosses	DF	PH (cm)	FL (cm)	FB (cm)	PL (cm)	PN	GP	TW (g)
1	Vandana/Hazaridhan	-4.98*	-3.496	0.61	0.091	1.055	7.221**	-0.901	-0.198
2	Vandana/ Sahabhagidhan	-1.002	14.083**	3.189	0.092	2.101**	3.021**	0.007	1.210
3	Vandana/ Kamesh	-0.145	-0.311	7.523**	0.191**	1.698*	-6.709**	28.928**	1.712
4	Vandana/ Virendra	0.098	-11.32**	1.845	0.107	1.210	0.171	0.345	1.975
5	Vandana/ Sahabhagidhan	5.567**	16.688**	-4.880*	-0.220**	0.986	13.271**	-16.28**	-0.856
6	Vandana/ NDR 97	4.021*	-6.912*	-6.091*	-0.116	-0.804	-0.41	30.271**	1.489
7	Vandana/ Shusk Samrat	5.575**	1.601	2.132	0.031	1.712*	1.495	10.001*	1.701
8	Hazaridhan/ Sahabhagidhan	-6.345**	-21.97**	-0.036	-0.081	-0.221	-2.502*	-1.905	-0.081
9	Hazaridhan/ Kamesh	6.844**	13.248**	-5.235*	-0.007	0.781	7.347**	3.698	1.857
10	Hazaridhan/Virendra	6.109**	8.112*	5.003*	-0.99	0.221	4.902**	22.935**	0.707
11	Hazaridhan/ Sahabhagidhan	2.971	6.421	-0.604	-0.067	-0.634	1.497	-9.780*	-1.64
12	Hazaridhan/ NDR 97	2.643	12.934**	-2.202	-0.003	1.523*	4.034**	-31.88**	-0.893
13	Hazaridhan/ Shusk samrat	0.132	13.093**	3.956	0.077	1.245*	-1.112	14.876**	-4.342**
14	Sahabhagidhan/ Kamesh	6.301**	15.098**	-2.918	-0.036	0.686	0.923	-25.29**	0.429
15	Sahabhagidhan/ Virendra	6.918**	11.008**	3.091	-0.009	1.308	0.094	26.956**	0.309
16	Sahabhagidhan/ Narendra-80	8.312**	0.595	2.43	0.161*	1.494*	-1.77	10.564 *	-2.354
17	Sahabhagidhan/ NDR 97	4.453*	23.143**	1.906	0.118	1.559*	9.694**	-6.006	1.291
18	Sahabhagidhan/ Shusk samrat	-5.406**	-41.80**	-7.089**	-0.236**	-3.289**	-11.03**	6.021	-1.123
19	Kamesh/ Virendra	5.543*	32.864**	3.521	0.154*	-0.018	6.705**	-22.05**	-0.899
20	Kamesh/ Narendra-80	-8.456**	-9.345*	2.698	0.203**	1.004	-2.453*	38.075**	-2.012
21	Kamesh/ NDR 97	-6.643**	-9.987**	0.289	-0.307**	0.308	-5.863**	41.897**	-0.210
22	Kamesh/ Shusk samrat	1.967	0.745	-6.879**	-0.289**	-0.605	13.982**	-5.987	-0.054
23	Virendra/ Narendra-80	-6.809**	-22.98**	9.987**	0.130	1.523*	-4.112**	38.986**	-1.309
24	Virendra/ NDR 97	-2.987	8.004*	0.998	0.912	0.414	8.319**	-11.987*	-2.821*
25	Virendra/ Shusk samrat	-4.553*	14.108**	1.311	0.088	1.532*	2.891**	-9.112*	0.416
26	Narendra-80/ NDR 97	-8.078**	1.310	3.013	0.029	-0.992	-3.023**	7.76	0.904
27	Narendra-80/ Shusk samrat	-3.602	14.011**	0.821	0.032	1.512*	-0.674	-19.98**	1.921
28	NDR 97/Shusk samrat	2.932	4.003	0.987	0.021	-0.134	-1.813	25.007**	0.924
29	SE (sij)	2.52	3.95	2.69	0.079	0.89	1.20	4.456	1.225

Table 4: Contd.....

S. No.	Crosses	GY (g)	KL (mm)	KB (mm)	LBR (mm)	AC	AS
1	Vandana/Hazaridhan	7.834**	0.008	0.053	-0.099	-0.019	-0.103
2	Vandana/ Sahabhagidhan	4.506**	0.275	-0.031	0.250	0.398	-0.259
3	Vandana/ Kamesh	2.845**	-0.201	0.034	-0.21	-0.603	0.299
4	Vandana/ Virendra	5.564**	0.289	-0.021	0.278	-0.596*	0.305
5	Vandana/ Sahabhagidhan	10.123**	1.002**	0.029	0.498*	0.701*	-0.19
6	Vandana/ NDR 97	19.043**	0.145	-0.059	0.265	0.918**	0.502*
7	Vandana/ Shusk Samrat	12.002**	-0.021	0.198**	-0.301*	0.495	-0.295
8	Hazaridhan/ Sahabhagidhan	-4.003**	0.041	-0.146*	0.401	0.099	-0.185
9	Hazaridhan/ Kamesh	14.012**	0.692	0.068	-0.142	-0.401	-0.019
10	Hazaridhan/Virendra	20.013**	0.121	0.021	-0.019	0.403	0.41
11	Hazaridhan/ Sahabhagidhan	-5.004**	-0.505*	0.184**	-0.589**	-0.192	0.302
12	Hazaridhan/ NDR 97	-14.89**	0.676**	-0.129*	0.626**	-0.081	0.502*
13	Hazaridhan/ Shusk samrat	-14.03**	0.756**	0.063	0.287	-1.341**	0.412
14	Sahabhagidhan/ Kamesh	-10.43**	0.723	0.101	0.197	-1.003**	0.312
15	Sahabhagidhan/ Virendra	10.954**	0.268	-0.098	0.402*	-1.587**	0.567*
16	Sahabhagidhan/ Narendra-80	0.476	-0.985	0.051	-0.453*	-0.703*	0.412
17	Sahabhagidhan/ NDR 97	12.532**	-0.324	0.198**	-0.491*	-0.397	0.069
18	Sahabhagidhan/ Shusk samrat	-2.814**	-0.612*	-0.132*	-0.041	0.383	-0.063
19	Kamesh/ Virendra	-3.325**	-1.203**	0.063	-0.804**	0.147	-0.565*
20	Kamesh/ Narendra-80	12.998**	0.290	-0.059	0.292	0.091	0.040
21	Kamesh/ NDR 97	7.689**	-0.193	-0.149*	0.194	-0.427	0.552*
22	Kamesh/ Shusk samrat	18.902**	-0.178	0.029	-0.176	0.745**	0.173
23	Virendra/ Narendra-80	11.008**	0.189	0.062	-0.018	-0.143	-0.602*
24	Virendra/ NDR 97	-0.702	-0.385	0.021	-0.282	-0.162	-0.139
25	Virendra/ Shusk samrat	-0.703	-0.081	0.041	-0.151	1.056**	-0.013
26	Narendra-80/ NDR 97	2.934**	0.165	0.014	0.062	-0.31	-0.514*
27	Narendra-80/ Shusk samrat	-9.213**	0.163	0.036	-0.197	0.367	-0.017
28	NDR 97/Shusk samrat	12.411**	-0.287	-0.062	-0.038	0.867**	0.517*

Where, C-1=Vandana/Hazaridhan, C-2=Vandana/ Sahabhagidhan, C-3=Vandana/ Kamesh, C-4=Vandana/ Virendra, C-5=Vandana/ Sahabhagidhan, C-6=Vandana/ NDR 97, C-7=Vandana/ Shusk Samrat, C-8=Hazaridhan/ Sahabhagidhan, C-9=Hazaridhan/ Kamesh, C-10=Hazaridhan/Virendra, C-11=Hazaridhan/ Sahabhagidhan, C-12=Hazaridhan/ NDR 97, C-13=Hazaridhan/ Shusk samrat, C-14=Sahabhagidhan/ Kamesh, C-15=Sahabhagidhan/ Virendra, C-16=Sahabhagidhan/ Narendra-80, C-17=Sahabhagidhan/ NDR 97, C-18=Sahabhagidhan/ Shusk Samrat, C-19=Kamesh/ Virendra, C-20=Kamesh/ Narendra-80, C-21=Kamesh/ NDR 97, C-22= Kamesh/ Shusk Samrat, C-23=Virendra/ Narendra-80, C-24=Virendra/ NDR 97, C-25=Virendra/ Shusk Samrat, C-26=Narendra-80/ NDR 97, C-27=Narendra-80/ Shusk Samrat, C-28=NDR 97/Shusk Samrat

Conclusion

Overall, parental lines used in the study, rice variety NDR 97and Kamesh could be utilised in hybridization programme because of its good general combining ability for yield and its components. Hybrids namely C-1 (Vandana/Hazaridhan), C-2 (Vandana/ Sahabhagidhan), C-3 (Vandana/ Kamesh), C-4 (Vandana/ Virendra), C-5 (Vandana/ Sahabhagidhan), C-6 (Vandana/ NDR 97), C-7 (Vandana/ Shusk Samrat), C-9 (Hazaridhan/ Kamesh), C-10 (Hazaridhan/Virendra), C-15 (Sahabhagidhan/ Virendra), C-17 (Sahabhagidhan/ NDR 97), C-20 (Kamesh/ Narendra-80), C-21 (Kamesh/ NDR 97), C-22 (Kamesh/ Shusk Samrat), C-23 (Virendra/ Narendra-80), C-26 (Narendra-80/ NDR 97) and C-28 (NDR 97/Shusk Samrat) could be utilised for development of short duration rice inbred with enhanced genetic gain. Breeding methodology like biparental mating among selected crosses or diallel selective mating to exploit both the additive and non-additive genetic components would be more purposeful in enhancing the genetic gain in short duration rice genotypes.

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