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Combining Ability and Heterosis in Rice (*Oryza sativa* L.) Cultivars

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ABSTRACT

Quantitative valuations of observed heterosis for 11 traits of 15 F_1 hybrids generated by half diallel crosses of six diverse rice cultivars (Domsefid, Hashemi and Binam, three Iranian local cultivars; Dorfak, Kadous and IR30, three improved cultivars), were made in this study. Fifteen F_1 hybrids and their parents were evaluated in a randomized complete block design with three replications at the Research Farm of the University of Guilan at Rasht, (Iran) in 2006. The studied traits were growth period, reproductive period, flag leaf area, plant height, panicle length, number of panicles per plant, number of grains per panicle, 1000-grain weight, grain yield, brown grain length and brown grain width. The significance of specific combining ability (SCA) and general combining ability (GCA) for all studied traits revealed that both additive and non-additive gene effects contributed to the inheritance of the traits. Assessment of standard heterosis based on check variety Dorfak showed that there was significant heterosis for all the traits studied in the 15 hybrids. For grain yield, the Dorfak×Domsefid cross had the highest heterosis. This hybrid had good heterosis values for many traits such as growth period, reproductive period and 1000-grain weight and was recommended as the most promising combination for developing high yielding hybrid rice varieties.

Keywords: General combining ability, Heterosis, Rice, Specific combining ability.

INTRODUCTION

Heterosis in rice was first reported by Jones (1926) who observed a marked increase in culm number and grain yield in some F_1 hybrids in comparison to their parents. Both positive and negative heterosis is useful in crop improvement, depending on the breeding objectives. In general, positive heterosis is desired for yield and negative heterosis for early maturity (Nuruzzaman *et al.,* 2002).

Heterosis is expressed in three ways, depending on the criteria used to compare the performance of a hybrid (Gupta, 2000). These three ways are mid-parents heterosis (the performance of a hybrid compared with the average performance of its parents), better parent heterosis or heterobeltiosis (the performance of a hybrid compared with that of the best parent in the cross) and standard heterosis (the performance of a hybrid compared with high yielding variety in the region). From a practical point of view, standard heterosis is the most important of the two levels of heterosis because it is aimed at developing desirable hybrids superior to the existing high yielding commercial varieties (Chaudhary, 1984). Heterosis breeding is an important genetic tool that can facilitate yield enhancement from between 30% to 400% and helps enrich

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many other desirable quantitative and qualitative traits in crops (Srivastava, 2000).

Breeding strategies based on hybrid production require a high level of heterosis as well as the specific combining ability (SCA) of crosses. One of the main problems of plant breeders for improving high yielding varieties is to select good parents and crosses. Diallel analysis is one of the most powerful tools for estimating the general combining ability (GCA) of parents and selecting of desirable parents and crosses with high SCA for the exploitation of heterosis (Sarkar *et al.,* 2002).

Positive heterosis for grain yield was reported by Virmani *et al.* (1982) for three levels of heterosis. The values ranged from 18-59%, 5-42% and 7-35% for mid-parent, better parent and standard heterosis, respectively. Significant GCA and SCA for yield and yield components were also reported by Borgohain and Sarma (1998). These researchers showed a high GCA to SCA ratio for grain yield/plant, plant height and days to 50% flowering, that indicated higher share of additive gene action than non-additive gene action. Li *et al.* (2002) used F_1 progenies of a 9×9 partial diallel design for evaluating heterosis. Their results showed significant positive heterobeltiosis for plant height, 1000-grain weight and grain yield in all F_1 hybrids. Significant negative heterobeltiosis was also observed for days to maturity. Furthermore, significant heterosis for most studied traits was showed by Hong *et al.* (2002) in a 8×8 full diallel design. The results showed that the share of additive and non-additive gene effects compared to controlling plant height, spikelet/panicle, grains/ panicle and grain yield/plot traits was equal. Also, the share of additive gene effects compared to controlling days to maturity, panicle length and number of effective tillers/plant was greater than non-additive gene effects. In contrast, the share of non-additive gene effects for 1000-grain weight was more. Alam *et al.* (2004) reported significant positive heterosis for plant height, days to maturity, number of fertile spikelets/panicle, number of effective tillers/hill, grain yield/10 hill and 1000-grain weight on three levels of heterosis. In addition, their results showed negative heterosis for days to flag leaf initiation, days to first panicle initiation, days to 100% flowering and days to maturity in most of crosses.

The objectives of this study were to evaluate GCA and SCA in rice cultivars and heterosis of different traits for identifying desirable cultivars and developing high yielding hybrid rice varieties.

MATERIALS AND METHODS

Six rice cultivars Hashemi, Binam, Dorfak, Kadous, Domsefid and IR30 were grown at the Research Farm of Faculty of Agricultural Sciences of the University of Guilan, Rasht (Iran) in 2005 and crossed in a half diallel mating design. In next growing season (2006), fifteen F_1 hybrids and their parents were planted in a randomized complete block design with three replications and 11 important agronomic traits were studied. The measured traits were growth period (days from seeding grain to 50 percent flowering per plot), reproductive period (days from 50 percent flowering to days to 50 percent maturity), flag leaf area (cm^2), plant height (cm), panicle length (cm), number of panicles per plant, number of grains per panicle, 1000-grain weight (g), grain yield (ton ha^{-1}), brown grain length (mm) and brown grain width (mm). Ten random plants per plot were used for measuring traits, except for grain yield for which the data was recorded on per plot basis. Data analysis was carried out based on third method of Gardner and Eberhart (1966). Standard heterosis (SV) was calculated as equation (1) by using of the standard variety Dorfak, and the level of heterosis was tested using the student's "*t*" test:

$$SV = \frac{\overline{F}_1 - \overline{SV}}{\overline{SV}} \times 100 \quad , \quad t = \frac{\overline{F}_1 - \overline{SV}}{\sqrt{Var(\overline{F}_1 - \overline{SV})}} \quad (1$$

where $\overline{F_1}$ and $\overline{SV}$ are the mean of F_1 progenies and standard variety Dorfak in all replications. GCA and SCA were calculated by using Equations (2) and (3), respectively.

$$g\hat{c}a_i = \frac{1}{p(p-2)}(p\,x_i.-2x..) \quad (2$$

$$s\hat{c}a_{ij} = x_{ij} - \frac{1}{p-2}(x_i.+x._j) + \frac{2}{(p-1)(p-2)}x.. \quad (3$$

Where x_{ij} is the *ith* replication for the *jth* parent (i= 1,...,r; j= 1,…,p), $x_i.$ is the sum of p genotypes for the *ith* replication, $x._j$ is the sum of r replications for *jth* genotype and $x..$ is the total sum of data (rp observations).

The significant tests for GCA and SCA effects were done using the *t* test with variances of these effects, which calculated by Equations (4) and (5), respectively:

$$Var(g\hat{c}a_i) = \frac{p-1}{p(p-2)}M'_e \quad (4$$

$$Var(s\hat{c}a_{ij}) = \frac{p-3}{p-1}M'_e \quad (5$$

Where M'_e is the $\frac{MSe}{r}$ ratio, and MS_e and *r* are the error mean square and the number of replications of randomized complete block design in the analysis of variance table (Table 1).

RESULTS AND DISCUSSION

The analysis of variance based on the third method of Gardner and Eberhart (1966) is shown in Table 1. Results showed that there were significant differences (P< 0.01) between genotypes for all studied traits. Mean squares of parents and crosses were significantly different at a 1% level of probability in the all traits. The difference between parents indicated that they are suitable for genetic studies. Also, the significance of SCA and GCA for all studied traits revealed that both additive and non-additive gene effects contributed in trait control. The role of additive and non-additive gene effects for controlling these traits were also reported by Borgohain and Sarma (1998) and Hong *et al.* (2002).

The significant mean squares of parents versus crosses in all studied traits, except for panicle length and the number of panicles per plant, indicates significant heterosis for these traits. Comparing Gardner-Eberhart method (Table 1) and estimating heterosis by using Equation (1) in Table 3, indicated that the two methods were nearly similar and showed the existence of heterosis.

GCA and SCA effects for different traits are given in Table 2. IR30, Kadous and Binam cultivars had higher significant positive GCA effects for the growth period. In particular, IR30 that had the most number of the growth period days. Furthermore, Hashemi, Dorfak and Domsefid cultivars had higher significant negative GCA for the growth period. Significant negative GCA effects for these parents showed that early maturity could be transferred to progenies. According to the kind of breeding target, it is possible to use parents with a high positive or negative GCA in breeding programs. For example, parents which have a high positive GCA for flag leaf area, grain yield, 1000-grain weight and brown grain length could be used in breeding programs. While for growth period and plant height, parents with a high negative GCA could be used.

Those crosses with high positive or negative SCA could also be used in relation to the target of a breeding program. For example, Dorfak×Kadous and Dorfak×IR30 had significant (P< 0.01) positive SCA for plant height, while their parents had significant (P< 0.01) negative GCA. On the other hand, the cross Binam×Domsefid had significant (P< 0.01) negative SCA, while their parents had significant (P< 0.01) positive GCA for plant height. These results may be due to non-additive gene effects in controlling this trait.

Comparison of the observed heterosis of hybrids and the GCA of their parents revealed that most of the good hybrids were usually generated from the crosses between parents with high and low GCA. Generally,

Table 1. Analysis of variance for studied traits based on the third method of Gardner and Eberhart.

Source of variation	df	Mean square of traits [a]										
		GP (days)	RP (days)	FLA (cm^2)	PH (cm)	PL (cm)	NPP	NGP	GW (g)	GY/H (ton)	BGL (mm)	BGW (mm)
Block	2	3.39^{ns}	0.11^{ns}	3.46^{ns}	8.46^{ns}	0.61^{ns}	0.66^{ns}	8.13^{ns}	0.22^{ns}	0.09^{*}	0.080^{ns}	0.004^{ns}
Genotypes	20	89.52^{**}	60.59^{**}	94.27^{**}	782.34^{**}	4.47^{**}	17.62^{**}	384.93^{**}	2.24^{**}	3.28^{**}	0.550^{**}	0.030^{**}
Parents	5	160.99^{**}	48.25^{**}	210.15^{**}	1226.48^{**}	4.57^{**}	35.19^{**}	568.38^{**}	2.29^{**}	4.26^{**}	0.820^{**}	0.003^{**}
Parents versus Crosses	1	102.43^{**}	11.91^{**}	9.03^{**}	111.51^{**}	0.01^{ns}	0.17^{ns}	617.26^{**}	4.41^{**}	3.15^{**}	0.080^{**}	0.040^{**}
Crosses	14	63.18^{**}	68.49^{**}	58.97^{**}	671.64^{**}	4.76^{**}	12.59^{**}	302.82^{**}	2.06^{**}	2.94^{**}	0.490^{**}	0.030^{**}
GCA	5	131.76^{**}	85.99^{**}	61.69^{**}	1501.11^{**}	9.68^{**}	23.10^{**}	447.02^{**}	1.73^{**}	3.70^{**}	0.870^{**}	0.040^{**}
SCA	9	25.07^{**}	58.77^{**}	56.74^{**}	210.81^{**}	2.02^{**}	6.75^{**}	272.73^{**}	2.24^{**}	2.51^{**}	0.270^{**}	0.030^{**}
Error	40	0.85	0.33	2.61	1.43	0.18	0.34	1.86	0.04	0.01	0.002	0.001

Note: ns' * and ** indicates non-significant and significant at 5% and 1% level of probability, respectively.
[a]: The symbol of traits are GP= Growth period; RP= Reproductive period,; FLA= Flag leaf area; PH= Plant height; PL= Panicle length; NPP= Number of panicle/plant; NGP= Number of grain/panicle;GW= 1000-grain weight; GY/H= Grain yield/hectare; BGL= Brown grain length, BGW= Brown grain width.

Table 2. General and specific combining ability based on the third method of Gardner and Eberhart for studied traits.

GCA and SCA effects		GP (day)	RP (day)	FLA (cm^2)	PH (cm)	PL (cm)	NPP	NGP	GW (g)	GY/H (ton)	BGL (mm)	BGW (mm)
Parents [b]	P_1	-9.58**	-0.47^{ns}	-4.16**	-0.57^{ns}	-0.93**	-1.52**	5.14**	0.61**	-0.64**	0.04^{ns}	-0.13**
	P_2	1.92**	3.69**	3.76**	28.17**	-0.18^{ns}	-1.19**	-12.86**	-0.21*	-1.33**	-0.19**	0.03^{ns}
	P_3	-0.92*	-7.89**	0.31^{ns}	-22.70**	-0.06^{ns}	-2.30**	17.80**	0.01^{ns}	1.19**	0.38**	0.05*
	P_4	3.25**	5.19**	-2.14**	-8.45**	-2.09**	-1.06**	-3.18**	0.74**	0.72**	0.49**	-0.002^{ns}
	P_5	7.33**	1.19**	-4.06**	-13.80**	2.50**	3.43**	-0.61^{ns}	-1.09**	-0.47**	-0.81**	0.16**
	P_6	-2.00**	-1.72**	6.29**	17.41**	0.76**	2.64**	-6.29**	-0.05^{ns}	0.52**	0.09*	-0.05*
Crosses	$P_1 \times P_2$	-7.33**	-0.33^{ns}	-4.41**	-2.55**	-1.22**	-2.06**	5.84**	-0.13^{ns}	-0.50**	-0.98**	0.04^{ns}
	$P_1 \times P_3$	3.17**	-11.08**	10.30**	9.38**	1.79**	2.59**	-7.49**	0.63**	-0.08^{ns}	-0.91**	0.07*
	$P_1 \times P_4$	3.33**	0.50^{ns}	-4.66**	-0.65^{ns}	-0.65^{ns}	-1.72**	4.76**	-0.44**	0.19*	0.31**	0.05*
	$P_1 \times P_5$	2.58**	1.17*	8.74**	-10.70**	0.31^{ns}	1.35**	6.13**	0.14^{ns}	0.18*	0.54**	-0.99**
	$P_1 \times P_6$	-1.75*	9.75**	-9.93**	4.53**	-0.24^{ns}	-0.16^{ns}	-9.24**	-0.31*	0.21**	0.23**	0.04^{ns}
	$P_2 \times P_3$	2.33**	7.75**	-1.42^{ns}	-2.87**	1.25**	1.75**	10.96**	1.23**	-2.48**	0.57**	0.09**
	$P_2 \times P_4$	4.17**	-4.00**	-4.45**	-1.15^{ns}	0.08^{ns}	-0.72^{ns}	-21.64**	-0.27^{ns}	1.93**	-0.32**	-0.09**
	$P_2 \times P_5$	-2.92**	-4.33**	0.01^{ns}	8.88**	0.003^{ns}	-1.15*	2.60*	-2.37**	0.40**	0.11**	0.11**
	$P_2 \times P_6$	2.75**	0.92*	10.30**	-2.31*	-0.12^{ns}	2.18**	2.24*	1.53**	0.65**	-0.18**	-0.15**
	$P_3 \times P_4$	-5.00**	3.58**	0.78^{ns}	4.34**	0.41^{ns}	0.86^{ns}	17.35**	-1.64**	-0.01^{ns}	0.42**	-0.14**
	$P_3 \times P_5$	-4.42**	9.25**	-5.65**	13.06**	-1.15**	-4.29**	-3.24**	1.28**	0.19*	-0.49**	0.14**
	$P_3 \times P_6$	2.92**	-9.50**	-3.98**	-25.90**	-2.31**	-0.91^{ns}	-17.58**	-1.49**	1.27**	0.41**	-0.14**
	$P_4 \times P_5$	3.08**	-2.50**	0.79^{ns}	-19.70**	-0.84*	3.39**	-15.28**	1.57**	0.17*	-0.06^{ns}	-0.05*
	$P_4 \times P_6$	-5.58**	2.42**	7.54**	15.19**	0.99**	-1.81**	14.80**	0.78**	-2.29**	-0.35**	0.36**
	$P_5 \times P_6$	1.67**	-3.58**	-3.89**	8.49**	1.67**	0.69^{ns}	9.78**	-0.61**	-0.94**	-0.11**	-0.01^{ns}

The column heads GP to BGW are grouped under the spanning heading "Traits [a]".

Note: ns, * and ** indicates non-significant and significant at 5% and 1% level of probability, respectively.

[a] The symbol of traits are same as in Table 1.

[b] The symbol of parents are P_1= Hashemi; P_2= Binam; P_3= Dorfak; P_4= Kadous; P_5= IR30, P_6= Domsefid.

highest heterosis was observed in crosses in which one of the two parents had low general combining ability. This indicated the role of both additive and non-additive gene action in producing heterosis. There were also a few hybrids with high heterosis values from the crosses between two parents with high general combining abilities. In many cases, however, the crosses of high×high GCA led to inferior hybrids for many studied traits, indicating epistatic gene actions in controlling these traits (Table 2). Sarkar *et al*. (2002) were also reported that several traits in rice were controlled by epistatic gene effects.

Standard heterosis of fifteen hybrids for all studied traits on the basis of the check variety Dorfak is presented in Table 3. The average of observed heterosis of each hybrid for each trait was compared with the standard variety. Significant positive or negative heterosis was observed in all traits. For growth period, except for the Kadous×IR30 hybrid which showed significant positive heterosis, most of the other hybrids including Hashemi×Binam, Hashemi×Dorfak and Hashemi×Domsefid hybrids showed significant negative heterosis. The observed heterosis was from -24.4 to 7.9 percent. This suggested the possibility of developing early maturity hybrids from these cross combinations. In contrast, all hybrids had high significant positive heterosis for the reproductive period, except the Hashemi×Dorfak and Dorfak×Domsefid hybrids which had significant negative heterosis. The heterosis values ranged from -36.4 to 110.91 percent for Hashemi×Dorfak and Hashemi×Domsefid, respectively (Table 3). Therefore, these crosses (i.e. Hashemi×Dorfak and Dorfak×Domsefid) were probably the best crosses for decreasing both growth and reproductive periods.

In the case of flag leaf area, all hybrids showed significant negative heterosis. The observed values ranged from -55.01 to -11.75 percent. For panicle length, number of panicles per plant, number of grains per panicle, grain yield and brown grain length, negative heterosis was also observed in most of the crosses. In contrast, significant positive heterosis was observed for plant height, 1000-grain weight and brown grain width. Except Kadous×IR30 hybrid which had significant negative heterosis of -8.3 percent for plant height, other crosses showed significant positive heterosis from 2.9 to 79.8 percent.

For grain yield, only the Dorfak×Domsefid hybrid showed significant positive heterosis. The observed heterosis ranged from -47.33 to 20.95 percent for the Binam×Dorfak and Dorfak×Domsefid hybrids, respectively. It seems that the Dorfak×Domsefid cross is the best promising combination for developing high yielding hybrid rice varieties.

Development of early maturity and high yielding varieties is desired in rice breeding programs. A short growth period, weather conditions and economic factors are the reasons for which these varieties are important. Among the 15 crosses, highly negative heterosis was observed in Hashemi×Binam, Hashemi×Domsefid for growth period, which indicated the possibility of developing early maturing lines. Negative heterosis for early maturing was also reported by Alam *et al.* (2004) and Nuruzzaman *et al.* (2002) in rice. Heterosis of rice hybrids was observed to vary in growth duration, ranging from 105 to 135 days (Virmani, 1998).

Increasing pests and diseases and partial harvesting of lodged plants can decrease grain quality. Thus, plant height is one of the most important factors to control lodging. In rice, grain yield and plant height have a significant negative correlation. In this study, negative heterosis for plant height was observed only in the Kadous×IR30 cross. Thus, this hybrid can be used to produce dwarf varieties in later breeding programs. Alam *et al.* (2004) and Nuruzzaman *et al.* (2002) also reported negative heterosis for rice plant height in several crosses.

Table 3. Standard variety (SV) heterosis in percentage for 11 studied traits in rice.

Crosses [b]	Traits [a]										
	GP (day)	RP (day)	FLA (cm^2)	PH (cm)	PL (cm)	NPP	NGP	GW (g)	GY/H (ton)	BGL (mm)	BGW (mm)
$P_1 \times P_2$	-24.4**	85.5**	-45.6**	60.9**	-14.9*	-38.7**	-6.6**	12.8**	-45.9**	-15.2**	2.4*
$P_1 \times P_3$	-15.9**	-36.4**	-28.3**	20.7**	-5.5^{ns}	-22.7**	2.3^{ns}	17.1**	-15.9**	-17.2**	7.3**
$P_1 \times P_4$	-10.9**	98.2**	-55.1**	25.1**	-18.9**	-36.6*	-2.2^{ns}	15.7**	-17.9**	-0.5^{ns}	3.9^{ns}
$P_1 \times P_5$	-7.2*	80.0**	-27.4**	9.2**	-2.2^{ns}	-2.3^{ns}	-0.2^{ns}	10.1**	-30.2*	-14.0**	0.5^{ns}
$P_1 \times P_6$	-22.7**	110.9**	-50.1**	57.2**	-9.1*	-12.7**	-10.9*	13.2**	-19.8**	-6.6*	0.9^{ns}
$P_2 \times P_3$	-2.7^{ns}	89.1**	-34.1**	37.8**	-4.8*	-24.9**	2.5^{ns}	16.1**	-47.3**	-1.5^{ns}	13.5**
$P_2 \times P_4$	3.0^{ns}	96.4**	-42.5**	54.3**	-14.4**	-30.5**	-25.1**	12.8**	-7.3**	-11.3**	1.9^{ns}
$P_2 \times P_5$	-0.9^{ns}	72.7**	-38.6**	59.1**	-0.9^{ns}	-12.1*	-11.2**	-4.6*	-24.9**	-22.2**	19.9**
$P_2 \times P_6$	-4.6**	85.5**	-11.8^{ns}	79.8**	-6.5*	-0.6^{ns}	-14.3**	17.2**	-22.4**	-14.6**	-3.1^{ns}
$P_3 \times P_4$	-10.6**	74.6**	-39.8**	9.4**	-13.1**	-28.4**	10.8**	7.7**	-1.3*	5.2*	2.2^{ns}
$P_3 \times P_5$	-5.3*	83.6**	-52.6**	10.8**	-4.0*	-31.4**	1.5^{ns}	12.5**	-11.2**	-22.6**	24.9**
$P_3 \times P_6$	-7.6**	-34.6**	-34.1**	2.9**	-12.7**	-19.6**	-8.8**	4.9*	20.9**	0.1^{ns}	0.8^{ns}
$P_4 \times P_5$	7.9**	90.9**	-46.5**	-8.3**	-9.1*	9.1^{ns}	-15.4**	16.9**	-16.4**	-15.9**	13.6*
$P_4 \times P_6$	-12.5**	101.8**	-20.1**	60.1**	-8.9^{ns}	-18.1**	-2.9^{ns}	18.1**	-31.3**	-8.1*	17.9**
$P_5 \times P_6$	0.9^{ns}	47.3**	-40.7*	47.6**	6.9**	13.6*	-4.2*	3.9*	-29.7**	-21.5**	12.8*

Note: ns, * and ** indicates non-significant and significant at 5% and 1% level of probability, respectively.

[a] The symbol of traits are the same as in Table 1.

[b] The symbol of parents are the same as in Table 2.

To increase grain yield in rice, varieties with low sterile spikelets and a high number of grains per panicle could be produced. Varieties with higher grain weight and more panicles per plant could also be selected. A high percentage of heterosis for grain yield and it's related traits were reported by Zhang *et al.* (1994), Li *et al*. (2002) and Alam *et al*. (2004). Li *et al.* (1997) suggested that epistasis might be an important genetic basis of heterosis in rice. Exploitation of heterosis for increasing grain yield in rice was reported by Virmani *et al.* (1991). In this study, the Hashemi×Binam, Hashemi×IR30, Binam×Dorfak and Kadous×Domsefid crosses were unsuitable combinations for the most traits. However, the Dorfak×Domsefid cross with the highest positive standard heterosis for grain yield was the best cross combination for developing high yielding hybrid rice varieties. Furthermore, this hybrid showed the good heterosis values for several important traits such as 1000-grain weight, growth period and reproductive period.

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قابلیت ترکیب‌پذیری و هتروزیس در ارقام برنج (*Oryza sativa* L.)

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چکیده

در این مطالعه، ارزیابی کمی هتروزیس مشاهده شده ۱۱ صفت در ۱۵ هیبرید $F_۱$ حاصل از یک طرح تلاقی نیمه دی‌آلل با شش رقم برنج مختلف (سه رقم بومی ایرانی دم‌سفید، هاشمی و بینام و سه رقم اصلاح شده درفک، کادوس و IR30) انجام شد. پانزده هیبرید $F_۱$ و والدینشان در یک طرح بلوک‌های کامل تصادفی با سه تکرار در مزرعه تحقیقاتی دانشکده علوم کشاورزی دانشگاه گیلان در سال ۲۰۰۶ ارزیابی شدند. صفات مورد مطالعه شامل دوره رشد رویشی، دوره رشد زایشی، سطح برگ پرچم، ارتفاع بوته، طول خوشه، تعداد خوشه در بوته، تعداد دانه پر در خوشه، وزن هزار دانه، عملکرد دانه، طول دانه قهوه‌ای و عرض دانه قهوه‌ای بود. معنی‌دار بودن قابلیت ترکیب‌پذیری عمومی (GCA) و خصوصی (SCA) برای تمامی صفات مورد مطالعه نشان داد که هر دو نوع اثرات افزایشی و غیرافزایشی ژن‌ها کنترل وراثت صفات را به عهده دارند. برآورد هتروزیس استاندارد نسبت به واریته شاهد درفک نشان داد که هتروزیس معنی‌داری برای همه صفات مطالعه شده در ۱۵ هیبرید حاصل وجود داشت. از نظر عملکرد دانه، تلاقی درفک × دم‌سفید دارای بالاترین مقدار هتروزیس بود. این هیبرید ارزش‌های خوبی برای بسیاری از صفات مانند دوره رشد رویشی، دوره رشد زایشی و وزن هزار دانه داشت و به عنوان بهترین ترکیب امید بخش برای توسعه ارقام هیبرید با عملکرد بالا در برنج توصیه می‌شود.