Analysis of combining ability effects for spike yield in six-row winter barley

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Abstract Choosing a hybridization method depends mostly on parental forms ability to combine wanted traits in new cultivar. Combining ability implicates possibilities of one parent to produce superior descendents, when it is crossed with another parent. The objective of the present study was conducted to assess the relative magnitude of GCA and SCA for grain weight/spike and to select the best combiner for successful hybridization in six row barley breeding. Six double haploid lines obtained through "bulbosum method" were chosen to suite the statistical model for genetic study.

The high sca effects of cross DH 33-3 x DH 21-2 might be attributed to additive x additive type of gene action and the high yield potential of these crosses can be fixed in subsequent generations.

The results obtained from F_1 and F_2 generations revealed that there is no direct relation between gca effects of parents and sca effects of hybrid combinations. This could be explained from the point of view of gene action since gca is mostly due to additive gene action whereas sca is mostly due to overdominance and epistasis.

Key words

winter barley, combining ability, spike yield

A significant yield improvement it is possible through the development of high yielding cultivars, having wide genetic base and capable of producing higher under various agro-climatic conditions [3]. For this purpose, basic knowledge of genetic architecture of yield and yield components and nature of gene action is required.

Diallelic hybridization is used a lot in genetic analysis of quantitative traits. When the breeding objective is constituted by a trait with simple heredity, choosing parental forms is not difficult. For quantitative traits, especially when we expect transgressions, the choice of parental forms is much difficult. Identification of genetically superior parents is an important prerequisite for developing promising strains [1]. For this, combining ability analysis provides useful information so as to select suitable parents for a hybridization program.A useful tool in this problem is the genetic study of first hybrid generations by diallelic crosses, when useful information can be obtained concerning the particularities of genetic system that generate that trait [6].

Among various genetic techniques, combining ability analysis developed by Griffing [4] provides important information for selection of parents in terms of the performance of their hybrids. Further it elucidates the nature and magnitude of various types of gene actions involved in the expression of quantitative characters. Combining ability has been defined and categorized originally by Spargue and Tatum [5] who described that high general combining ability (GCA) effects were due to additive type of gene action, whereas high specific combining ability (SCA) indicated non-additive gene effects.

The objective of the present study was conducted to assess the relative magnitude of GCA and SCA for grain weight/spike and to select the best combiner for successful hybridization in six row barley breeding.

Biological Material and Method

Six parental forms were chosen to suite the statistical model for genetic study, different by origin and the phenotypic expression of traits. The double haploid lines uses as parental forms were obtained through "bulbosum method" in INCDA Fundulea.

Table 1

Origin of the doubled haploid lines

No	Genotype	Origin	No	Genotype	Origin
1.	DH 19-1	F 529/84	22	DH 23-2	Miraj
2.	DH 20-4	F 208/88	23	DH 26-2	Adi
3.	DH 21-2	F 503/88	24	DH 33-3	F 549/88

In order to obtain hybrid combinations, parental forms were introduced in a diallelic incomplete hybridization type *n(n-1)/2*, making simple crosses between them in 2005/2006, obtaining 15 hybrid combinations, direct hybrids respectively. Hybrid generations F_1 and F_2 were obtained in period of 2007 and 2008. Combining ability analysis was carried out using method 2, model I as suggested by Griffing [4].

Results and Discussions

Regarding the number of grains weight/spike, differences between hybrids F_1 are due to general and as well specific combinative ability in approximately equal insignificant measure. Variances ratio values between GCA/SCA (0,74) shows that the determinism of this trait to studied genitors is mainly due to nonallelic interactions.

Table 2

Variance analysis of combining ability for grain weight/spike in F_1 hybrids

Variability source	SS	DF	MS	F Test
General combining ability	0.15	5	0.032	0.47 ($F_{5\%}$=2.49)
Specific combining ability	0.63	15	0.042	0.63 ($F_{5\%}$=1.95)
Error	2.34	35	0.067	
GCA/SCA			0.74	

General combining ability of a parent is the average performance of a parent in a series of crosses. The mean effects of the general combining ability were small and insignificant with an 0,15 g amplitude, from -0,08 g in line DH 33-3 to 0,07 g for DH 23-2 line, but highly correlated with the grains weight/spike to parental forms (r = 0,828*). According to analysis of variance for combining ability, it is observed that there aren't significant differences between studied lines in terms of their value as genitors for spike yield.

Table 3

Effects of general and specific combining ability for grain weight/ spike in F_1 hybrids

Parental forms	General combining ability effects	Specific combining ability effects				
		DH 23-2	DH 21-2	DH 20-4	DH 19-1	DH 26-2
DH 33-3	-0.08	0.15	0.45*	-0.05	-0.15	-0.11
DH 23-2	0.07		-0.09	0.35	0.01	-0.09
DH 21-2	0.07			0.02	0.14	0.03
DH 20-4	0.02				-0.13	0.01
DH 19-1	0.02					-0.11
DH 26-2	0.04					

$LSD_{5\%}$ = 0.18g $LSD_{1\%}$ = 0.25g $LSD_{0.1\%}$ = 0.33g LSD = 0.45g LSD = 0.61g $LSD_{\%}$ = 0.80g

The specific combining ability effects are also reduced and varied,generally insignificant. with an amplitude of 0.60g, and strongly correlated with values of F_1 hybrids (r = 0.910**). The largest positive effects were seen in hybrids: DH 33-3 x DH 21-2 (0.45*) şi DH 23-2 x DH 20-4 (0.35). The lowest effects were presented by the combinations: DH 33-3 x DH 19-1 (-0.15) şi DH 19-1 x DH 26-2 (-0.11).

The crosses like DH 33-3 x DH 21-2 originated from high general combiner parents reflecting high sca effects are expected to produce useful transgressive segregants, which can be identified following simple conventional breeding technique like pedigree method of selection [2]. The high sca effects of such crosses might be attributed to additive x additive type of gene action and the high yield potential of these crosses can be fixed in subsequent generations.

The differences between F_2 hybrids in terms of spike yield are due to general and as well specific combinative ability in approximately equal insignificant measure. Values of ratio GCA/SCA show that genes with additive effect are mainly involved in determinism of this trait.

Table 4

Variance analysis of combining ability for grain weight/spike in F_1 hybrids

Variability source	SS	DF	MS	F Test
General combining ability	0.19	5	0.038	1.92 ($F_{5\%}$=2.49)
Specific combining ability	0.35	15	0.024	1.18 ($F_{5\%}$=1.95)
Error	0.70	35	0.02	
GCA/SCA			1,61	

Consistent with results from F_1, the mean effects of the general combining ability, was small and insignificant with an magnitude of 0.17 g, from -0,10 g in DH 21-2 line to 0,07 g to DH 26-2 line, but highly correlated with spike yield of the parental forms (r = 0.979*). For this generation DH 26-2 was the best general combiner followed by DH 19-1 line.

Table 5

Effects of general and specific combining ability for grain weight/ spike in F_2 hybrids

Parental forms	General combining ability effects	Specific combining ability effects				
		DH 23-2	DH 21-2	DH 20-4	DH 19-1	DH 26-2
DH 33-3	-0.07	0.12	0.34**	0.1	-0.13	-0.08
DH 23-2	0.04		-0.04	0.24	-0.12	-0.10
DH 21-2	-0.10^0			-0.07	0.10	0.03
DH 20-4	-0.01				-0.07	-0.12
DH 19-1	0.06					0.02
DH 26-2	0.07					

$LSD_{5\%}$ = 0.10g $LSD_{1\%}$ = 0.13g $LSD_{0.1\%}$ = 0.18g LSD = 0.25g LSD = 0.33g $LSD_{\%}$ = 0.44g

The effects of specific combinativ ability are low and with different sign, generally insignificant, except DH 33-3 x DH 21-2, with a magnitude of 0.47 g and strongly correlated with the values recorded in F_1 hybrids (r = 0.812**). In case of this hybrid, the high SGA value is the result of a low x low GCA combination of the parents.

The highest effects of specific combinative ability in both generations were observed in combinations DH 33-3 x DH 21-2 and DH 23-2 x DH 20-4, and the lowest value in hybrid DH 33-3 x DH 19-1 (-0,13).

Conclusions

In the present study, low x low gca combination also produced hybrids with high sca (DH 33-3 x DH 21-2) and this could be attributed to overdominance or epistatic gene action.

The high sca effects of such cross might be attributed to additive x additive type of gene action and the high yield potential of these crosses can be fixed in subsequent generations.

The results obtained from F_1 and F_2 generations revealed that there is no direct relation between gca effects of parents and sca effects of hybrid combinations. This could be explained from the point of view of gene action since gca is mostly due to additive gene action whereas sca is mostly due to overdominance and epistasis.

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