



## Inheritance of the Grain Number per Spike in Diallel Cross of 5x5 Bread Wheat Cultivars

Nataša Ljubičić · Sofija Petrović · Miodrag Dimitrijević · Nikola Hristov

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**Summary:** This study examined the mode of inheritance and the influence of genes on the grain number per spike in  $F_1$  generations, in 5x5 half diallel crosses of wheat cultivars. The results of the combining ability analysis did not indicate significant differences among the parents for general combining ability (GCA) and crosses for specific combining ability (SCA) for the grain number per spike. The GCA/SCA ratio tilted in favour of the SCA in this trait, which indicated the preponderance of non-additive gene, i.e. dominant effects in the genetic control of grain number per spike. Components data of genetic variance and regression analysis indicated a greater role of the dominant component in the grain number per spike inheritance. The regression line intercepts the  $W_r$  axis below the origin in  $F_1$ , indicating over-dominance over an average of all arrays.

**Keywords:** combining ability, components of genetic variance, gene effects, genetic inheritance, grain number per spike, regression analysis, wheat

### Introduction

Considering the importance of wheat production, the question on the wheat production increase has been imposed. Wheat production in a country can be increased either by bringing more area under cultivation or by developing new, high yielding cultivars. Obtaining wheat cultivars with high genetic potential for grain yield is the main goal of breeding programs (Petrović et al. 2012). Since this trait is very complex, includes many quantitative components and has a polygenic inheritance, breeders normally use yield components to improve the grain yield, despite the fact that these components compensate each other in practice and increase in one causes a decrease in the other (Vaezi et al. 2000, Foroozanfar & Zeynali 2013). Therefore, the mode of inheritance of yield components is a permanent subject of study. Having the knowledge about the nature and magnitude of gene effects for yield traits and their expression are of the major importance in formulating efficient breeding programs (Inamullah 2004). Diallel analysis, as one of several models which is

available to plant breeders, is a suitable method for estimating of genetic parameters and provides early information on the genetic behaviour of these traits in the first generation (Farshadfar et al. 2012).

The aim of this study was to establish GCA and SCA in half diallel crosses of five cultivars, gene effect for grain number per spike, as well as to identify the best cultivar combiner and the best progeny of crosses combination.

### Materials and Methods

Five wheat genotypes (cvs. Pobeda, Renesansa, Sara, Partizanka and Pesma), were crossed in possible combinations following an 5 x 5 diallel mating system and  $F_1$  generation of progenies was obtained. The experiment was conducted at the trial field of the Institute of Field and Vegetable Crops in Novi Sad, according to random block design with three replications, in three growing seasons (2009/2010, 2010/2011 and 2011/2012). The cultivars were sown in 2 m long rows with 20 cm of inter-row spacing and 10 cm spacing between plants in the row. The number of grains per spike of plants at the stage of full maturity was analysed. The main sample consisted of 10 plants per replication. Average values of three-year trait analysis were used. General combining ability (GCA) and specific combining ability (SCA)

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N. Ljubičić\* · S. Petrović · M. Dimitrijević  
University of Novi Sad, Faculty of Agriculture, Dpt. Genetics and Plant Breeding, 8 Trg Dositeja Obradovića, 21000 Novi Sad, Serbia  
e-mail: ljubicic.natasa@gmail.com

N. Hristov  
Institute of Field and Vegetable Crops, 30 Maksima Gorkog, 21000 Novi Sad, Serbia

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were made following the method 2 (parents and  $F_1$  generation) mathematical model 1 of Griffing (1956). The regression analysis and the components of genetic variance were analysed by using methods of Mather and Jinks (1971).

## Results and Discussion

Based on the mean values of the parents and their progenies in the  $F_1$  generation, the analysis of variance of the combining ability was made and presented in Table 1. The results of the analysis did not indicate significant differences for the general (GCA) and specific (SCA) combining ability in the  $F_1$  generation, meaning that grain

number per spike resulted from the genes with additive and non-additive effects. According to Fehr (1993), when GCA nor SCA values are not significant, then epistatic gene effects play an important role in the determination of this trait. The GCA/SCA ratio tilted in favour of SCA in this trait, which had amounted to 0.88. This indicates the preponderance of non-additive gene, i.e. dominant effects in the genetic control of grain number per spike. The value of ratio GCA/SCA in our study was similar to findings of Petrović et al. (2012), while Hassan et al. (2007) and Dagustu (2008) observed the greater significance of the additive component in the inheritance of the grain number per spike.

Table 1. Analysis of variance for combining ability for the grain number per spike in a 5 x 5 diallel cross of wheat

Source of variance	DF	SS	MS	$F_t$		
				F	0.05	0.01
GCA	4	21.67	5.42	1.06 <sup>ns</sup>	2.69	4.02
SCA	10	61.29	6.13	1.20 <sup>ns</sup>	2.16	2.98
E	28	428.51	5.10			
GCA/SCA				0.88		

\*GCA: General Combining Ability, SCA: Specific Combining Ability, E: Error; DF: Degree of Freedom, SS: Sum of Squares, MS: Mean Square, F: Level of Significance by the F test; Significant ( $P < 0.05$ ), Highly significant ( $P < 0.01$ ), Non-significant (ns)

Table 2. General combining ability values for the grain number per spike of wheat

Parents	GCA Values	Rank	LSD		
			SE	0.05	0.01
Pobeda	0.876 <sup>ns</sup>	1			
Renesansa	-0.132 <sup>ns</sup>	3	1.207	2.44	3.26
Sara	0.851 <sup>ns</sup>	2			
Partizanka	-1.195 <sup>ns</sup>	5			
Pesma	-0.402 <sup>ns</sup>	4			

\*GCA: General Combining Ability, SE: Standard Error; LSD: Least Significant Difference test; Significant ( $P < 0.05$ ), Highly significant ( $P < 0.01$ ), Non-significant (ns)

Estimates of general combining ability are given in Table 2. Estimates of combining ability revealed that the tendency of the largest value of positive GCA effects were observed in genotype Pobeda followed by genotype Sara, suggesting that these genotypes contain more genes with additive effects and could be a good parent for this trait. Genotype Partizanka was the poorest general combiner with maximum negative, but not significant, GCA effects. Negative GCA effects were also observed in Pesma and Renesansa.

Estimates of specific combining ability are given in Table 3. In this study, crosses which displayed high specific combining ability effects for the grain number per spike were obtained from parents with various types of general combining ability effects (high x low). Estimates of SCA effects showed tendency of the highest positive value for crosses

Sara/Partizanka (3.421) and Pobeda/Partizanka (3.362), with non-significant values. Tendency of higher values of SCA effects was also observed in crosses Pobeda/Pesma (2.173) and Sara/Pesma (1.761). Greater SCA effects obtained in these crosses (low x high), which involved one parent with high GCA, indicated the involvement of additive x dominance gene interaction in the expression of this trait. The highest negative value for estimates of SCA effects was shown by Renesansa x Sara (-0.187). Negative SCA effects were also observed in crosses Pobeda x Renesansa (-0.668) and Pobeda x Sara (-0.095). According to Borojević (1986), parents with high values of SCA are good combination of filial generation, which uses dominant gene action, but for wheat parents that show a high GCA are more important and are used in cases where the selection is performed in subsequent generations.

Table 3. Specific combining ability values for the grain number per spike of wheat

Parents	LSD						0.05	0.01
	Pobeda	Renesansa	Sara	Partizanka	Pesma	SE		
Pobeda		-0.668 <sup>ns</sup>	-0.095 <sup>ns</sup>	3.362 <sup>ns</sup>	2.173 <sup>ns</sup>			
Renesansa			-0.187 <sup>ns</sup>	0.425 <sup>ns</sup>	0.218 <sup>ns</sup>	2.70	5.45	7.29
Sara				3.421 <sup>ns</sup>	1.761 <sup>ns</sup>			
Partizanka					0.126 <sup>ns</sup>			

SCA: Specific Combining Ability, SE: Standard Error; LSD: Least Significant Difference test; Significant ( $P < 0.05$ ), Highly significant ( $P < 0.01$ ), Non-significant (ns)

Figure 1 revealed that the regression analysis ( $V_r/W_r$ ) indicated super dominance for the number grains per spike because regression line intersected the  $W_r$  axis below the origin. The estimated regression line did not deviate significantly from the unit slope ( $b=0.720 \pm 0.250$ ), which suggests the absence of non-allelic interaction. The arrays that correspond to parents were similarly distributed along the regression line and they indicate that the parents were genetically divergent for the analysed trait. The varieties Renesansa, Sara and Pobeda had higher dominant genes, but variety

Partizanka which is far away from the origin had higher recessive genes for the grain number per spike in wheat. The genotype Pesma had an equal proportion of both genes. The arrays that correspond to parents were similarly distributed along the regression line and they indicate that the parents were genetically divergent for the analysed trait. The similar findings, which indicated over-dominance type of gene action, were also obtained by Akram (2004), Perišić et al. (2011) and Petrović et al. (2012), while Minhas (2012) reported a partial mode of inheritance of the grain number per spike.

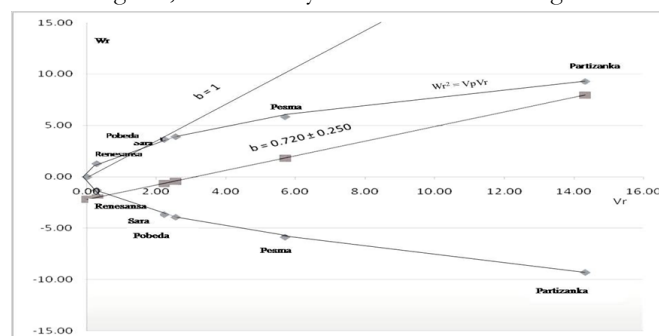


Figure 1.  $V_r/W_r$  regression analysis for the grain number per spike ( $b$ : Coefficient of Regression,  $W_r$ : Covariance,  $V_r$ : Variance)

Inheritance of the grain number per spike, analysed by components of genetic variance is shown in Table 4. The components of variance ( $H_1$  and  $H_2$ ) resulting from dominant gene action in  $F_1$  generation are greater than the variance component  $D$ , which is the result of their additive action. Unequal values of  $H_1$  and  $H_2$  suggested that positive and negative alleles were unequal among parent cultivars. The frequency of the dominant allele ( $u = 0.67$ ) was greater than the frequency of recessive allele ( $v = 0.33$ ), which is in agreement with the calculated  $F$  value (interaction additive  $\times$  dominant effect), which is positive, as well as the value of  $H_2/4H_1$ . The average degree of dominance ( $\sqrt{H_1/D} = 2.38$ ) has greater values than 1, which indicated over-dominance type of gene action in the inheritance of the grain number per spike, which was in accordance with the results obtained by regression analysis. The ratio of the total number of dominant against recessive alleles ( $K_d/K_r$ ) is greater than 1, indicating the presence of more dominant alleles in inheritance of this trait. Similar results, which indicated a larger value of the dominant component in the genetic variance and over-dominant inheritance of the grain number per spike, have been pointed out by Rahman et al. (2000),

Hassan (2004), Akram et al. (2009), and Petrović et al. (2012). Contrary to these results, the greatest part of the additive component in the inheritance of the grain number per spike was observed by Minhas (2012).

Table 4. Genetic components of variation for the grain number per spike

Components	Values
D	1.27
$H_1$	7.23
$H_2$	6.43
F	1.21
E	5.10
$H_2/4H_1$	0.22
$u = p$	0.67
$v = q$	0.33
$\sqrt{H_1/D}$	2.38
$K_d/K_r$	1.50

+D: Measures additive effect,  $H_1$  and  $H_2$ : Measures dominance effect, F: Determines frequencies of dominant to recessive alleles in parents, E: Shows environment effect,  $(H_1/D)^{1/2}$ : Measures average degree of dominance,  $H_2/4H_1$ : Determines proportion of genes with positive and negative effects in the parents,  $(4DH_1)^{1/2} + F / (4DH_1)^{1/2} - F$ : Measures proportion of dominant and recessive genes in the parents,  $u$ : The values of dominant alleles,  $v$ : The value of recessive alleles,  $\sqrt{H_1/D}$ : The average degree of dominance, ( $K_d/K_r$ ): Ratio of the total number of dominant against recessive alleles.

## Conclusions

According to the analysis of variance for combining ability it is concluded that both additive and non-additive gene effects were responsible for the inheritance of the grain number per spike. Specific effects were greater than the general effects, which suggests an important role for non-additive genetic effects in the expression of the grain number per spike. The importance of dominant genetic effects in the inheritance of this trait was also confirmed using the analysis of the component the genetic variance. Tendency of the largest values of GCA were obtained from parents with various types of general combining ability effects, which in our case was the combination high x low in crosses: Sara/Partizanka, Pobeda/Partizanka, Pobeda/Pesma and Sara/Pesma. The regression analysis in F<sub>1</sub> generations indicated over-dominant inheritance of the number of grains per spike, which was confirmed using the analysis of the components of the genetic variance. Regression coefficient in F<sub>1</sub> generation was not significantly different from unity which indicates the absence of interallelic interaction for the number of grains per spike.

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## Nasleđivanje broja zrna po klasu u dialelnom ukrštanju 5x5 hlebne pšenice

Nataša Ljubičić · Sofija Petrović · Miodrag Dimitrijević · Nikola Hristov

**Sažetak:** U radu je ispitan način nasleđivanja i efekat gena za osobinu broj zrna po klasu kod F<sub>1</sub> generacije u dialelnom ukrštanju pšenice (5x5). Analizom varijanse kombinacionih sposobnosti nisu utvrđene značajne razlike u opštim (GCA) i posebnim kombinacionim sposobnostima (SCA). Odnos GCA/SCA je ukazao da su u nasleđivanju broja zrna po klasu preovladali neaditivni efekti gena. Rezultati analize komponenata genetičke varijanse i regresione analize su ukazali na veći značaj dominantne komponente u nasleđivanju broja zrna po klasu. Regresionom analizom ustanovljen je superdominantan način nasleđivanja broja zrna po klasu u F<sub>1</sub> generaciji, s obzirom na to da je linija regresije sekla ordinatu ispod koordinatnog početka.

**Cljučne reči:** broj zrna po klasu, genski efekti, kombinacione sposobnosti, komponente genetičke varijanse, nasleđivanje, pšenica, regresiona analiza