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GENTIC ANALYSIS OF YIELD COMPONENTS IN WINTER WHEAT (*Triticum aestivum ssp. vulgare* L.)

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The mode of inheritance, gene effect, combining ability and genetic components of variance for length of spike, number of spikelets per spike and number of kernels per spike in 4 divergent cultivars (Srbijanka, Partizanka, KG-56 and PKB-111) were studied in diallel crosses (without reciprocals). Cultivars and F_2 hybrids showed great differences for the analyzed traits. This study showed that the mode of inheritance for all analyzed yield components was different with preponderance of partial dominance. The best general combiner for length of spike was Partizanka cultivar, while for number of spikelets per spike and number of kernels per spike it was Srbijanka cultivar.

Key words: wheat, cultivar, length of spike, number of spikelets/spike, number of kernels/spike, combining ability, inheritance

INTRODUCTION

The aim of a breeding program is the creation of new genotypes with high yield and quality. Breeding success depends on genetic variability of the starting material from which new cultivars are selected. Many genotypes created by

breeding, may be used to create new wheat cultivars which may be grown in different environmental conditions. For successful breeding, besides the genetic variability of the initial material, it very important to know the mode of inheritance and genetic variability components for other traits (KRALJEVIĆ-BALALIĆ *et al.*, 1982). Namely, the combining ability of the genotypes which will used as parents should be known wheat cultivars with good combining ability are used in breeding programs for improving other traits and providing descendants with positive characteristics.

The aim of this work was to investigate the combining ability and mode of inheritance for length of spike, number of spikelets/spike and number of kernels/spike in several wheat cultivars.

MATERIALS AND METHODS

In diallel crosses (without reciprocals) 4 divergent cultivars of wheat (Srbijanka, Partizanka, KG-56 and PKB-111) were examined. The experiment was performed in a randomized block design in three replications in the experimental field of the Center for Small Grains, Kragujevac. Parents and F_2 hybrids were grown on the experimental field during the period (1992/93). The seeds were sown in 1 m long rows, with 0,25 m spaces between the rows and 0,10 m distance between each seed in the row. The length of spike, number of spikelets/spike, number of kernels per spike in the parents of F_2 generation were analyzed in the full maturity stage with 60 plants (20 plants per replication). Combining abilities were analysed according to GRIFFING (1956), method 2, model I. Genetic evaluation of additive and non additive genetic effects and the relation between dominant and recessive genes was carried out using the method of HAYMAN (1954) and JINKS (1954).

RESULTS AND DISCUSSION

Length of spike. – Length of spike is an important characteristic which has a greater influence on grain yield over number of spikelets/spike. Long spikes are a higher source and acceptor of assimilates (STOJANOVIĆ, 1993), and influence plant production. In selection of wheat cultivars with large grain (JOVANOVIĆ *et al.*, 1992), it is necessary to select for long spikes (above 13 cm).

In this study Partizanka cultivar (10.52 cm) had the greatest length of spike and the lowest value was for KG-56 cv. (8.42 cm). The results showed partial dominance, intermediate dominance and heterosis in the inheritance of length of spike depending on the crossing combination. The greates length of spike was found in the cross combination Srbijanka x Partizanka (9.88 cm), where partial dominance was present. These results are in agreement with those of BHULLAR *et al.*, (1985). The cross combination Srbijanka x PKB-111 had the shortest spike

(9.32 cm), where negative heterosis was present. An intermediate mode of inheritance for this trait was established for cross combination Partizanka x KG-56 (Table 1).

Table 1. Mean value and inheritance of length of spike (P and F_2)

Cultivar	Srbijanka	Partizanka	KG-56	PKB-111
Srbijanka	9.48	9.88^{pd}	8.74^{pd}	9.32^{-h}
Partizanka		10.52	9.53^{i}	9.45^{-h}
KG-56			8.42	9.47^{pd}
PKB-111				10.38

Analysis of variance for combining ability showed that GCA and SCA were highly significant. The length of spike was under additive and dominant gene control, which is in agreement with the results of KNEŽEVIĆ and KRALJEVIĆ-BALALIĆ (1989) and SHERIFI (1990). The ratio GCA/SCA showed that additive components were about 5 times higher than non additive components (Table 2).

Table 2. Analysis of variance of combining ability for length of spike

Source of variation	DF	SS	MS	F	Ft	
					0.05	0.01
GCA	3	2.43	0.81	32.50**	3.2	5.1
SCA	6	0.90	0.15	6.06**	2.7	4.0
E	18		0.02			
GCA/SCA		5.36				

Partizanka cv. had the highest value of GCA which means that this cultivar was the best general combiner for length of spike (Table 3).

Table 3. GCA values for length of spike

Parents	Values	Rank	SE	LSD	
				0.05	0.01
Srbijanka	-0.13	3	-	-	-
Partizanka	0.37	1	0.09	0.19	0.26
KG-56	-0.45	4	-		
PKB-111	0.22	2	-		

KG-56 x PKB-111 crossing combination had the highest value for specific combining ability (Table 4).

Table 4. SCA values for length of spike

Direct cross	Value	LSD	
		0.05	0.01
Srbijanka x Partizanka	0.11	-	-
Srbijanka x KG-56	-0.21	0.38	0.52
Srbijanka x PKB-111	-0.30		
Partizanka x KG-56	0.08		
Partizanka x PKB-111	-0.67**		
KG-56 x PKB-111	0.17		
SE = 0.18			

The analysis of genetic components showed that dominant components mostly affect the inheritance of this trait (additive component - D is lower than dominant - H_1 and H_2). These results are in agreement with those of ALI-ZADE (1981) and KAPOOR and LUTHRA (1990) and in disagreement with the results of TSILKE *et al.*, (1979) and GILL *et al.*, (1983). This confirms the higher frequency of dominant (u) over recessive alleles (v), ant the degree of dominance ($\sqrt{H_1 / D}$ =1.57) which was higher than one (Table 5).

Table 5. Components of genetic variance for length of spike

Components of variance	Values in F_2 generation
D	0.75
F	0.79
H_1	1.86
H_2	1.64
$H2/4H_1$	0.22
$\sqrt{H_1 / D}$	1.57
u	0.67
v	0.32
Kd/Kr	2.00
E	0.02

Number of spikelets/spike. – The number of spikelets/spike depends on the length and compactness of the spike. It is desirable that wheat cultivars have intermediate spike compactness, which will in a heavy structure make 18 spikelets with about 3 grains per spikelet (BOROJEVIĆ, 1972).

In this investigation had Srbijanka cv. the highest number of spikelets/spike (21.06), and Partizanka cv. the lowest. (19.70). The cross combination KG-56 x PKB-111 had the most spikelets/spike, where partial dominance was present. Partial dominance was established in the other cross combinations,

except for Srbijanka x KG-56 where negative heterosis was present, and Partizanka x PKB-111 and KG-56 x PKB-111, where positive heterosis was present (Table 6). The number of spikelets/spike is controlled by genes with additive, dominant (ALI-ZADE, 1981) and partial dominant effects (HSU and WALTON, 1970).

Table 6. Mean value and inheritance of number spikelets/spike (P and F_2)

Cultivar	Srbijanka	Partizanka	KG-56	PKB-111
Srbijanka	21.06	20.63^{pd}	19.98^{-h}	20.84^{pd}
Partizanka		19.70	19.92^{pd}	20.87^{+h}
KG-56			20.14	20.91^{+h}
PKB-111				20.03

Analysis of variance for combining ability showed that GCA was significant, but SCA was highly significant. This means that inheritance of number of spikelets/spike in controlled by genes with additive and nonadditive effects, but the influence of additive gene effects is higher. These results are in agreement with those of KRALJEVIĆ-BALALIĆ and DIMITRIJEVIĆ (1992) and SHERIFI (1990). The participation of additive and dominant gene effects in the inheritance of this trait was similar (ratio GCA/SCA<1), table 7.

Table 7. Analysis of variance of combining ability for number of spikelets/spike

Source of variation	DF	SS	MS	F	Ft	
					0.05	0.01
GCA	3	0.72	0.24	4.46*	3.2	5.1
SCA	6	1.90	0.32	5.87**	2.7	4.0
E	18		0.05			
GCA/SCA		0.76				

Srbijanka cultivar had the highest GCA value, for number of spikelets/spike (Table 8).

Table 8. GCA values for number of spikelets/spike

Parents	Values	Rank	SE	LSD	
				0.05	0.01
Srbijanka	0.17	1	-	-	-
Partizanka	-0.29	4	1.34	0.28	0.39
KG-56	0.09	2	-		
PKB-111	0.02	3	-		

Partizanka x PKB-111 cross combination had the best specific combining ability (Table 9).

Table 9. SCA values for number of spikelets/spike

Direct cross	Value	LSD	
		0.05	0.01
Srbijanka x Partizanka	0.24	-	-
Srbijanka x KG-56	-0.79	0.56	0.77
Srbijanka x PKB-111	0.14		
Partizanka x KG-56	-0.39		
Partizanka x PKB-111	0.62		
KG-56 x PKB-111	0.29		
SE=0.27			

The analysis of genetic components showed that partial dominance ($\sqrt{H_1 / D} < 1$), negative and positive heterosis were prevalent in the inheritance of number of spikelets/spike. Dominance played a more important role in the inheritance of number of spikelets/spike than additive variance (H1 and H2 are higher than the value of parameter D). The F value (additive x dominance effect) was positive, which means that in the intheritance of number of spikelets/spike dominant alleles prevailed over recessive alleles. That is confirmed by the ratio of number of dominant and recessive alleles (Kd/Kr=3.17, Table 10). These results are in agreement with those of other investigators (ALI-ZADE, 1981; HSU and WALTON, 1970).

Table 10. Components of genetic variance for number of spikelets/spike

Components of variance	Values in F_2 generation
D	0.47
F	1.56
H_1	4.78
H_2	3.28
$H2 / 4H_1$	3.18
$\sqrt{H_1 / D}$	0.17
u	0.78
v	0.22
Kd/Kr	3.17
E	0.05

Number of kernels/spike. The results showed that there were significant differences in mean values between the parents for number of kernels/spike. The highest number of kernels/spike was established in Srbijanka cv. (68.40), and the lowest in KG-56 cv. (53.19). The cross combination Srbijanka x PKB-111 (59.01) had the highest value for this trait, where negative heterosis was present in the

inheritance of number of kernels/spike. Negative heterosis and the lowest value for this trait were present in cross combination Partizanka x PKB-111 (51.96). Partial dominance was present in the cross combinations Srbijanka x Partizanka and Srbijanka x KG-56 (Table 11).

Table 11. Mean value and inheritance of nubmer of kernels/spike (P and F2)

Cultivar	Srbijanka	Partizanka	KG-56	PKB-111
Srbijanka	68.40	57.38^{pd}	55.96^{pd}	59.01^{-h}
Partizanka		55.88	52.04^{-h}	51.96^{-h}
KG-56			53.19	57.58^{pd}
PKB-111				60.41

Analysis of variance for combining ability showed that GCA was highly significant, but SCA was significant. This means that additive gene effects played a more important role in the inheritance of number of kernels/spike. This is confirm by the ratio GCA/SCA, where additive components were about 5 times higher than non additive components (Table 12).

Table 12. Analysis of variance of combining abiltiy for number of kernels/spike

Source of variation	DF	SS	MS	F	Ft	
					0.05	0.01
GCA	3	151.93	50.64	16.52**	3.2	5.1
SCA	6	61.15	10.19	3.32*	2.7	4.0
E	18		3.07			
GCA/SCA		4.97				

The highest GCA value, statistically much higher than the other cultivars, for number of kernels/spike was shown by Srbijanka cultivar. The remaining cultivars had worse combining ability for this trait (Table 13).

Table 13. GCA values for number of kernels/spike

Parents	Values	Rank	SE	LSD	
				0.05	0.01
Srbijanka	3.88**	1	-	-	-
Partizanka	-2.13	3	1.01	2.12	2.91
KG-56	-2.32	4	-		
PKB-111	0.58	2	-		

The cross combination KG-56 x PKB-111 had the highest value for specific combining ability for number of kernels/spike (Table 14).

Table 14. SCA values for number of kernels/spike

Direct cross	Value	LSD	
		0.05	0.01
Srbijanka x Partizanka	-1.55	-	-
Srbijanka x KG-56	-2.78	4.25	5.82
Srbijanka x PKB-111	-2.63		
Partizanka x KG-56	-0.69		
Partizanka x PKB-111	-3.67		
KG-56 x PKB-111	2.15		
SE=2.02			

The number of kernels/spike was under the influence of additive and non additive gene effects, where dominance prevailed over additive. Partial dominance ($\sqrt{H_1 / D} < 1$) and negative heterosis was established, in the inheritance of number of kernels/spike. The frequency of dominant alleles (u) was higher than the frequency of recessive alleles (v), which indicated that genes with a dominant effect prevailed in the inheritance of this trait. That was confirmed by the values of the additive and dominant components (D<H1 and H2). The F value (additive x dominance effect) was positive, which means that in the inheritance of number of kernels/spike dominant prevailed over recessive alleles. That is supported by the ratio of number of dominant and recessive alleles (Kd/Kr=1.70; Table 15). These results are in agreement with those of other investigators (KRALJEVIĆ-BALALIĆ et al., 1982; GILL *et al.*, 1983; BHULLAR *et al., 1985;* SINGH et al., 1988; KNEŽEVIĆ and KRALJEVIĆ-BALALIĆ, 1989; NANDA et al., 1989; ANGELOV, 1990; DIMITRIJEVIĆ and KRALJEVIĆ-BALALIĆ, 1992).

Table 15. Components of genetic variance for number of kernels/spike

Components of variance	Values in F_2 generation
D	41.37
F	30.45
H_1	83.55
H_2	82.13
$H2/4H_1$	1.42
$\sqrt{H_1 / D}$	0.24
u	0.56
v	0.43
Kd/Kr	1.70
E	3.07

CONCLUSION

Analysis of variance showed significant values of GCA and SCA. The ratio GCA/SCA for length of spike and number of kernels per spike showed higher additive gene action than non additive gene action of their inheritance. The GCA/SCA ratio for number of spikelets per spike showed that non additive gene action prevailed in its inheritance.

The best general combiner for length of spike was Partizanka cultivar, while for number of spikelets per spike and number of kernels per spike it was Srbijanka cultivar.

The best cross combination for length of spike and number of kernels per spike was KG-56 x PKB-111, while for number of spikelets per spike it was Partizanka x PKB-111. These combinations are promising for breeding new genotypes for the studied traits.

Analysis of the genetic components of variance showed a preponderance of dominant genes in relation to recessive genes for the analyzed traits.

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GENETIČKA ANALIZA KOMPONENTI PRINOSA KOD OZIME PŠENICE (Triticum aestivum ssp. vulgare)

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Izvod

U radu je proučavan način nasleđivanja, efekat gena, kombinacione sposobnosti i komponente genetičke varijanse za dužinu klasa, broj klasića po klasu i broj zrna po klasu kod četiri sorte ozime pšenice (Srbijanka, Partizanka, KG-56 i PKB-111), koje su ukrštene po metodu nepotpunog dialela (bez recipročnih). Analize su urađene za roditelje i F2 hibride. Sorte i F2 hibridi su pokazali značajne razlike za ispitivana svojstva. Ustanovljeno je da u nasleđivanju ispitivanih komponenti prinosa učestvuju geni sa aditivnim i neaditivnim efektima, s' tim što veći značaj imaju aditivni geni. Kod svih proučavanih osobina preovlađuje parcijalna dominacija. Najbolje opšte kombinacione sposobnosti za dužinu klasa ispoljila je sorta Partizanka, a za broj klasića po klasu i broj zrna po klasu sorta Srbijanka. Najveća vrednost posebnih kombinacionih sposobnosti za dužinu klasa i broj zrna po klasu ustanovljena je kod kombinacije KG-56 x PKB-111, a za broj klasića po klasu kod kombinacije Partizanka x PKB-111.

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