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GENETIC CORRELATIONS AND PATH-COEFFICIENT ANALYSIS OF YIELD AND QUALITY COMPONENTS IN WHEAT *(TRITICUM AESTIVUM* L.)

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The genetic and phenotypic correlations between yield components (productive tillering, plant height, spike length, number of spikelets per spike, number of grains per spike, grain weight per spike, grain weight per plant, harvest index, thousand grain weight) and quality components (grain protein content and sedimentation value) were investigated. The plant material was comprised of 50 genotypes of winter wheat grown during two years. Path coefficient analysis of genetic correlation coefficients for grain mass/plant and other traits determined interrelationships among grain mass per plant and other yield and bread making quality components. The strongest positive genetic correlation was found between grain weight per spike and thousand grain weight and between spike length and number of spikelets per spike. Phenotypic correlation analysis indicated that grain weight per spike correlated positively and significantly with harvest index and thousand kernel weight. The strongest direct effect on grain weight per plant had harvest index and number of spikelets per spike. The spike length through number of spikelets per spike had the strongest indirect effect on grain weight per plant.

Key words: Triticum aestivum, genetic correlations, phenotypic correlations, path-coefficient analysis, yield components, bred making quality

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INTRODUCTION

The correlations are very important in plant breeding, because of its reflection in dependence degree between two or more traits. If there is genetic correlation between traits, in the case of direct selection of one trait can cause change in other trait. Correlations between traits are depending of genetic and environmental factors (FALCONER, 1981). Environmental conditions can cause variability, not only of some trait but interrelationships between its.

Correlation's themselves express only the degree of traits interrelationships, while path analysis provides analytically better survey of yield expression, as a resultant of its components. But it is not point to nature of that dependence. Its necessary calculate path analysis of correlation coefficients, because this method enable quality and complete recognize ratio between investigation components. Existing correlation between components, expressed through correlation coefficients, separate on direct and indirect influence by method path (LI, 1975; PENCHEV and STOEVA, 1989; GARCIA DEL MORAL *et al.*, 1991). Path coefficients divided correlation coefficients into a measure of direct and indirect effects within a system of correlated traits. If there have been genetic relations among traits, selection for a one trait would result in modification of another one, i.e. correlation response to selection would be obtained (TRIFuNovi, 1995). Path coefficients show direct influence independent variable upon dependent variable, but indirect influence one independent variable through other independent variable on dependent variable is describe results between coefficient simple correlation two independent of variables and their separate direct influence (IvANOvie', 1984).

Agro ecological conditions are exert influence on change, not only yield and yield components, then its can challenge differences of its reciprocal correlation (MALIK *et al.,* 1987). The knowledge of genetic and phenotypic interrelationships between yield and quality components is giving additional information that are make possible successful work of wheat breeding.

The aim of this paper is to compare the results obtained from genetic and phenotypic correlations and path coefficient analysis of yield and quality components in wheat and to demonstrate the significance of path coefficient analysis in determining the nature of character associations.

MATERIAL AND METHODS

Fifty ecogeographically diverse wheat genotypes from different selection centers in Yugoslavia and other countries (Russia, Italy, Great Britain, SAD, Japan, Hungary, Bulgaria, China, Poland, Belgium, Brazil, Rumania, France and Croatia) were examined.

The experiment was conducted in a randomized block design in three replications in the experimental field of the Center for Small grains. Kragujevac, during two years. The seed were sown in 1.0 m long rows, with 0.20 m spaces between the rows and 0.10 m between each seed in the row. A total of 60 plants were analyzed in full maturity stage (20 plants per replication).

Yield components were obtained by the standard methods, and the harvest index was computed as the ratio: HI=grain mass/grain weight + straw weight.

The grain protein content determined by the *Kjeldahl* method and sedimentation value by the *Zeleny* method (KALUDERSKI and FILIPOVIC, 1998).

Analysis of variance and covariance was computed using a randomized block design with two factors (HADZivuKovi, 1991). The genetic and phenotypic correlation coefficients were calculated from the variance and covariance components by the method described by FALCONER (1981). The significance of correlation coefficients was estimated using t-test.

The path coefficient analysis was performed according to EDWARDS (1979), using genetic correlations, to assess direct and indirect influences of different yield and quality components (productive tillering, plant height, spike length, number of spikelets per spike, harvest index, 1000 grain weight-TGW and sedimentation) on grain weight per plant.

RESULTS AND DISCUSSION

Genetic and phenotypic correlations. - Genetic and phenotypic correlation coefficients for all possible comparisons are presented in Table **1.** Highly significant and positive genetic and phenotypic correlation existed between grain weight per plant and follow components: grain weight per spike ($r_g=0.475$; $r_p=0.472$), harvest index ($r_g=0.481$ $r_p=0.445$) and TGW ($r_g=0.561^{x}$; $r_p=0.433^{*}$')), what is in agreement with results obtained by BHATT, 1973; LASKIN and MASLOVSKAYA, 1988; DOLOTOVSKIY and NIKONOV, 1989. Grain weight per plant was positively and significantly correlated with spike length ($r_8=0.346$'; $r_p=0.301$'). Phenotypic correlation between grain weight per plant and productive tillering were positive and high significant ($r_p=0.483^{—}$). Genetic correlation between productive tillering and grain protein content was high significant and positive ($r_g=0.443$ but productive tillering was negatively and significantly correlated with grain weight per spike ($r_g=-0.752$; $r_p=-0.454^{*\cdot}$). The genetic correlation between productive tillering and number of grains per spike ($r_g=-0.511^{*}$')) was negative and high significant, what is in agreement with studies carried out by ENDAIE and WAINES, 1989. Also, genetic correlation between productive tillering and number of spikelets per spike ($r_g=-0.323^{*}$) was negative and significant. Plant height and spike length were in high significant and positive genetic and phenotypic correlation ($r_g=0.483^{—}$; $r_p=0.459^{**}$). Plant height and TGW was positively and significantly correlated ($r_g=0.298$; $r_p=0.311$ **),** what was confirmed by BHATT, 1973. Genetic and phenotypic correlations between plant height and number of grains per spike were negative and high significant ($r_g=-0.440^{*}$; $r_p=-0.422$"·). The genetic correlation between plant height and harvest index ($r_g=-0.346$") was negative and significant, what is in agreement with (ENDAIE and WAINES, 1989), and

Table 1. Genetic (r_g- over diagonal) and phenotypic correlation coeficients (rp- under diagonal) of investigation components

Components	1	2	3	4	5	6	7	8	9	10	11
1. Grain weight per plant		0.041	0.242	0.346	-0.099	0.049	0.475$^{k''}$	0.481'	0.561		0.122
2. Productive filtering	0.483:			-0.198	-0.323'	-0.511	-0.752	-0.202	-0.205	0.443	0.064
3. 0.307	Plant height 0.181			0.217	0.082	0.483"	0.034	-0.440	-0.154	-0.346'	0.298 -
4.Spike lenght	0.301"	-0.121	0.459^{-}		0.613	0.286'	0.169	-0.174	0.047	-0.679	0.101
5.Numbr of spikelets/spike	0.009	-0.169	0.036	0.528'		0.502	0.118	-0.562""^{Y}	-0.310	-0.534""	-0.162
6. Number of grains/spike -0.299'		0.103	-0.263	-0.422	0.29W		0.438	0.437$^{'1'}$	0.241	-0.367	-0.328'
7. Grain weight/ spike	0.472'	-0.454'	-0.137	0.177	0.112	0.019		0.686	0.648 -	-0.156	-0.176
S Harvest index	0.445	-0.198	-0.259	-0.180	-0.388;	0.159	0.563		0.381'		-0.001
9. TCW	0.433	-0.115	0.311'	0.013	-0.240	-0.398'	0.535	0.358.		0.275	0.082
l0.Grain protein content	-0.032	0.155	-0.209	-0.345	-0.293	-0.163	-0.108	-0.261	0.180		-0.208
11.Sedimentation	0.110	0.021	0.163	0.066	-0.118	-0.262	-0.150	-0.012	0.086	-0.066	

Significant at 0.05 (*) and 0.01 (") level between plant height and grain protein content (r_g=-0.307) was significant and negative. Spike length were positively and significantly correlated with number of spikelets per spike (r_g=0.613; r_p=0.528$^{*'}$), and with number of grains per spike (r_g= 0.286'; r_p=0.290). However, spike length was negatively and significantly correlated with grain protein content (r_g=-0.679*; r_p=-0.345'). Highly significant positive genetic and phenotypic correlation existed between number of spikelets per spike and number of grains per spike (r $_g$=0.502 ; 4=0.438), and hiahly significant negative genetic and phenotypic correlation existed between number of spikelets per spike and harvest index (r_g=-0.562"; r_p=-0.388). Number of spikelets per spike was negatively and significantly correlated with grain protein content (r_g=-0.534; r_p=-0.293*). Genetic correlation between number of spikelets per spike and TGW was negative and significant (r,=-0.310). Number of grains per spike and TGW was in highly significant and negative genetic and phenotypic correlations (r_g=-0.367 ; r_p=-0.398*), what is in agreement with studies carried out by ENDAIE and WAINES (1989). Genetic correlation between number of grains per spike and grain weight per spike was highly significant and positive (r_g= 0.437.'), while correlation among number of grains per spike and grain protein content was highly significant and negative (r_g=-0.328). However, number of grains per spike was negatively and significant correlated with sedimentation (r_g=0.299). Genetic and phenotypic correlation between grain weight per spike and harvest index (r_g=0.686'*; r_p=0.563' '), and grain weight per spike and TGW (r_g=0.648 r_f=0.535**) were positive and highly significant, and agree with previous studies (DOLOTOVSKIY and NIKONOV, 1989). Harvest index were positively and significantly correlated with TGW (r_g= 0.381**; r_p= 0.358). Genetic correlation among TGW and grain protein content (r_g= 0.275) was positive and significant. These results are in accordance with the results obtained by DOLOTOVSKIY and NIKONOV (1989); ENDAIE and WAINES (1989). The rest genetic and phenotypic correlation coefficients were insignificant.

Path analysis for grain weight per plant. - Estimates of direct effect path coefficients and indirect effect path coefficients are presented in Table 2. High significant positive and medium strong direct effect of productive filtering

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(p_{yi}=0.557·), plant high ($p_{y,}$=0.497 .) and TGW (p_{y6}=0.401) on grain weight per

plant were established. Our results are in agreement with results obtained by BHATT, 1973 and KONOVALOV *et al.*, 1987. The number of spikelets per spike had positive and highly significant (p_{y4}=0.980**) direct influence on grain weight per plant. The effect of harvest index on grain weight per plant was positive and highly significant and very strong $(1)_{3,5}$=1.124'). Indirect influence of productive tillering through number of spikelets per spike on grain weight per plant was middle strong and negative ($r_{i4}p_{3.4}$= -0.318). The plant high through harvest index had middle strong and negative ($r_{25}p_{y5}$=-0.389) indirect influence on grain weight per plant. Strong positive indirect influence of spike length through number of spikelets per spike (r34p_y4=0.601), and strong negative indirect influence of number of spikelets

Table 2. Path-coefficient analysis for grain weight per plant

Direct effects	Indirect effects			
p_{y1}=0.557"	ri2Py2= 0.056	$r_{i3}p_{y3}$= 0.044		ri5p0= -0.226
P_y2=0.497""	r21Pyi= 0.062	$r_{23}p_{),3}$= -0.108	1_{24}14P_p:4$_4$:-0.318	r2511y5= -0.389
p_{y3}=-0.223	$r_{31}p_{yl}$= -0.1 10	$r_{32}p_{y2}$= 0.240	r34Py4= 0.601	r35p,r5= -0.196
p_{y4}=0.980	r4iP_yi= -O. 180	$r_{42}p_{y2}$= 0.017	$r_{43}p_{y3}$= -0.136	r45p5.5-, -0.632
p_{y5}= I . 1 24"'	$r_{5I}p_{yl}$= -0.112	$r_{52}p_{y2}$-= -0.172	$r_{53}p_{,3}$= 0.039	rs4P0= -0.551
p_{y6}=0.40 1 "	r_{61} $fl_{y,}$. -0. 1 14	$r_{62}p_{y2}$= 0.148	r63Py3= -0.010	r64py4= -0.304
p_{y7}=0. 146	$r_{73}p_{yl}$=0.036	$r_{72}p_{y-,}$= 0.090	$r_{73}p_{y3}$= -0.022	1-74Py4= -0.159
R. 1214567=0.753				

Legend: r_1- productive tillering; r_2- plant height; r_3- spike length; r_4- number of spikelets/spike; r_5- harvest index; r_6- TGW; r_7- sedimentation per spike through harvest index ($r_{45}p_{y5}$=-0.632) on grain weight per plant were established. The correlation coefficient between harvest index ($r_{54}p_{y4}$=-0.551) and TGW ($r_{64}p_{y4}$=-0.304) through number of spikelets per spike on grain weight per plant showed medium strong and negative indirect 'influence, what is in agreement with results obtained by BHATT, 1973. The indirect effect of TGW through harvest index on grain weight per plant was positive and medium strong ($r_{65}p_{y5}$=0.428), Table 2.

CONCLUSION

According to the results obtained, the following can be concluded:

The genetic correlation analysis indicated that the strongest positive effect were found between grain weight per spike and TGW (0.648**) and between spike length and number of spikelets per spike (0.613**). The strongest phenotypic correlation were found between grain weight per spike and harvest index (0.563**) and grain weight per spike and TGW (0.535**).

The direct effect of harvest index (1.124**) and number of spikelets per spike (0.980**) on grain weight per plant were positive and highly significant. The spike length (0.601) had the strongest indirect positive effect on grain weight per plant. The strongest negative effect on grain weight per plant had the number of spikelets per spike (-0.632) via harvest index.

The path-coefficient analysis gave a somewhat different picture from what the simple correlation analysis did. For example, the simple genetic correlation coefficient between plant height and grain weight per plant (r_g=0.242) was low. The path-analysis, however, exposed plant height (0.497**) as an important influencing factor on grain weight per plant. The genetic correlation analysis indicated spike length as an important positive influence on grain weight per plant, but path coefficient analysis suggested that spike length had direct negative influence on grain weight per plant.

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Genetičke korelacije i path-analiza komponenti prinosa i kvaliteta kod pšenice *(Triticum aestivum* L.)

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Izvod

U radu su proučavane korelacije izmedju komponenti prinosa (produktivno bokorenje, visina biljke, duZina klasa, broj klasida po klasu, broj zrna po klasu, masa zrna po klasu, masa zrna po biljci, 2etveni indeks i masa 1000 zrna) i komponenti kvaliteta (sadržaj proteina u zrnu i sedimentacija). Izračunate su genetičke i fenotipske korelacije i path- analiza genetinih koeficijenata korelacije za masu zrna po biljci. Najjka korelaciona zavisnost utvrdjena je izmedju broja zrna po klasu i mase zrna po klasu, a zatim izmedju visine biljke i dužiine klasa. Ustanovljena je jaka pozitivna genetitka korelacija izmedju mase zrna po klasu i mase 1000 zrna, kao i izmedju dužine klasa i broja klasida po klasu, dok je najjka fenotipske korelacija utvrdjena izmedju mase zrna po klasu i letvenog indeksa, a zatim izmedju mase zrna po klasu i mase 1000 zrna. Najjkl direktni uticaj na masu zrna po biljci imali su žetveni indeks i broj klasića po klasu. Od pozitivnih indirektnih uticaja na masu zrna po biljci najja6 je bio uticaj dužine klasa preko broja klasića po klasu.

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