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PATH ANALYSIS FOR MORPHOLOGICAL TRAITS IN MAIZE (*Zea mays* L.)

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Pavlov J., N. Delić, K. Marković, M. Crevar, Z. Čamdžija, and M. Stevanović (2015*): Path analysis for morphological traits in maize (Zea mays L..)*- Genetika, Vol 47, No. 1, 295-301.

Six inbred lines were crossed according to incomplete diallel method. In this way fifteen hybrid combinations were obtained. Hybrid combinations derived from these parental components were used in this work. The objective of study was to estimate direct and indirect effects of five morphological traits on grain yield by the application of the simple coefficient correlation and path coefficient analysis. The trait number of leaves above the top ear with the value of 0.736 has the strongest direct positive effect on grain yield. Positive direct effects on grain yield were also observed for height to tassel base and plant height, while negative direct effects were observed for ear height and total number of leaves. As far as indirect effects were considered, a positive effect of the ear position height on yield over the total plant height stands out. The evaluation of the proportion of mutual effects of five observed morphological traits on grain yield, expressed by the coefficient of multiple determination (R^2_{y12345}) amounted to 0.7881.

Key words: correlations, maize, path analysis

INTRODUCTION

Maize is one of the leading species in the global agricultural production ranking high in the world economy. It ranks first according to total production quantity and grain yield per area unit and second according to harvested areas in the world (FAOSTAT, 2013). In order to develop promising genotypes, it is essential to know the associations among different traits, especially

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with grain yield, which is the most important ultimate objective in any breeding programme (MALIK *et al*., 2005). It is necessary to have a good knowledge of those characters that have significant association with yield because the characters can be used as indirect selection criteria to enhance the mean performance of varieties in a new plant population (OJO *et al*., 2006). Grain yield is a complex quantitative trait that depends on a number of factors. It is within great influence of environmental conditions, has complex mode of inheritance and low heritability (BOĆANSKI *et al*., 2009). The correlation studies simply measure the associations between yield and other traits. Correlation between various characters is of great value as it indicates the degree to which various characters of a plant are associated with the economic productivity (AHSAN *et al*., 2008). The association between two characters can be directly observed as phenotypic correlation, while genotypic correlation expresses the extent to which two traits are genetically associated. Both genotypic and phenotypic correlations among and between pairs of agronomic traits provide scope for indirect selection in a crop breeding programme (MUHAMMAD and MUHAMMAD, 2001).

Path coefficient analysis has been widely used in crop breeding to determine the nature of relationships between grain yield (response variable) and its contributing components (predictor variables), and to identify those components with significant effects on yield for potential use as selection criteria (MOHAMMADI *et al*., 2003). This analysis permits the separation of correlation coefficient into direct and indirect effects (RAFIQ *et al*., 2010). Path-coefficient analysis measures the direct influence of one variable on another. Each correlation coefficient between a predictor variable and the response variable is partitioned into its component parts: the direct effect or path coefficient (a standardized partial regression coefficient) for the predictor variable and indirect effects, which involve the product of a correlation coefficient between two predictor variables with the appropriate path coefficient in the path diagram (DEWEY and LU, 1959; SHOKAT *et al*., 2011). By determining the inter-relationships among grain yield components, a better understanding or both the direct and indirect effects of the specific components can be attained.

MATERIALS AND METHODS

Six inbred lines were crossed according to incomplete diallel method and fifteen hybrids were created. These hybrids, were studied in two locations (Zemun Polje and Becej) during 2008. The two-replicate trial was set up according to the RCB design. The selected genotypes were sown in the two-rowed plot. The length of the plot was 4 m, the inter-row distance amounted to 75 cm and the sowing density was 70,175 plants per hectare. Morphological traits were evaluated after maize pollination. Sowing and harvesting were done by hand.

The objective of the study was to estimate direct and indirect effects of five morphological traits on grain yield by the application of the path coefficient analysis (EDWARDS, 1979). Statistical processing was done by MS Excel 2007 and MSTAT-C (1989).

Simple correlation coefficients among morphological traits were used for the formation of the symmetric correlation matrix (R_{ij}) of independent variables (5x5). Path coefficients P'_{yi} were estimated by the multiplication of an inverted matrix R_{ij} (R^{-1}_{ij}) with a vector R_{yi} (correlation coefficients of grain yield as a dependent variable with an independent variable).

RESULTS

Results displayed in Table 1., show values of simple correlation coefficients between examined traits. When it comes to correlation between grain yield and observed traits, the highest correlation values were found between grain yield and number of leaves above ear (0.851**), followed by total number of leaves (0.768**), plant height (0.752**) and height to tassel base (0.738**). The lowest value of correlation coefficient, which was below statistical significance was observed between ear height and grain yield (0.380).

The highest and statistically significant values of correlation coefficients among observed morphological traits were found between plant height and height to tassel base (0.989**), followed by total number of leaves and number of leaves above ear (0.842**). Total number of leaves, also showed high positive correlation coefficients with plant height and height to tassel base (0.825**).

Table 1. Correlation coefficients of grain yield and component traits in maize

	GY	HTB	PH	EH	TNL	NLE
GY	1	0.738**	0.752**	0.380	0.768**	0.851**
HTB	0.738**	1	0.989**	0.704**	0.825**	0.779**
PH	0.752**	0.989**	1	0.688**	0.825**	0.795**
EH	0.380	0.704**	0.688**	1	0.505*	0.572**
TNL	0.768**	0.825**	0.825**	0.505*	1	0.842**
NLE	0.851**	0.779**	0.795**	0.572**	0.842**	1

***GY= grain yield, HTB= height to tassel base, PH=plant height, EH=ear height, TNL= total number of leaves, NLE=number of leaves above top ear

*P<0.05; ** P<0.01

Results of PATH analyis are presented in Table 2.

Table 2. Combined direct and indirect effects of morphological traits on grain yield in maize at locations Zemun Polje and Becej

	HTB	PH	EH	TNL	NLE	GC
HTB	**0.366**	0.362	0.258	0.302	0.285	1.573
PH	0.049	**0.050**	0.035	0.041	0.040	0.215
EH	-0.222	-0.217	**-0.316**	-0.160	-0.181	-1.096
TNL	-0.028	-0.028	-0.017	**-0.034**	-0.029	-0.136
NLE	0.573	0.585	0.422	0.620	**0.736**	2.936

R^2_{y12345}=0.7881

***GY= grain yield, HTB= height to tassel base, PH=plant height, EH=ear height, TNL= total number of leaves, NLE=number of leaves above top ear, GC=Genetic correlation with grain yield

The most positive direct effect of examined traits to grain yield was found for number of leaves above ear (0.736), also positive direct effects were found for height to tassel base (0.366) and plant height (0.050). Negative direct effects were found for remaining two traits, ear height (-0.316) and total number of leaves (-0.034). For all traits which had positive direct effect on grain yield, positive indirect effects were also observed. On the other side, for ear height and

total number of leaves, which had negative direct effect, their indirect effects through other traits were also negative.
Values of path coefficients per locations are presented in Tables 3 and 4.

Table 3. Direct and indirect effects of morphological traits on grain yield in maize at location Zemun Polje

	HTB	PH	EH	TNL	NLE
HTB	**0.119**	0.088	0.087	0.064	0.091
PH	-0.051	**-0.068**	-0.055	-0.030	-0.055
EH	-0.263	-0.289	**-0.361**	-0.241	-0.356
TNL	-0.007	-0.006	-0.008	**-0.013**	-0.008
NLE	0.876	0.922	1.129	0.753	**1.146**

***GY= grain yield, HTB= height to tassel base, PH=plant height, EH=ear height, TNL= total number of leaves, NLE=number of leaves above top ear

Table 4. Direct and indirect effects of morphological traits on grain yield in maize at location Becej

	HTB	PH	EH	TNL	NLE
HTB	**0.221**	0.190	0.177	0.125	0.177
PH	0.068	**0.079**	0.062	0.042	0.061
EH	-0.337	-0.329	**-0.422**	-0.307	-0.417
TNL	-0.054	-0.051	-0.069	**-0.095**	-0.067
NLE	0.896	0.869	1.110	0.791	**1.122**

***GY= grain yield, HTB= height to tassel base, PH=plant height, EH=ear height, TNL= total number of leaves, NLE=number of leaves above top ear

Similar results of path coefficients between location were obtained. Highest positive vaules of direct effects were observed for trait number of leaves above ear (1.146 and 1.122), while highest negative direct effects were recorded for ear height (-0.361 and -0.422). Impact of number of leaves above ear on grain yield was higher on separate locations than on both locations in total. Contrary, direct effect of height to tassel base on grain yield was stronger on both locations in total, than at separate locations.

DISCUSSION

Obtained high and positive simple correlation coefficients between observed traits were also reported by ZIREHZADEH *et al.*, (2011) who also determined significant values (P=0.05) of correlation coefficient between grain yield, plant height, number of leaves and number of leaves above ear. BOĆANSKI *et al.*, (2009) found high and significant correlation between ear height and grain yield, which is partially in accordance with our results. The highest and statistically significant correlations that were found between plant height and height to tassel base and number of leaves above ear and grain yield, which leads to conclusion that breeding on higher number of leaves above ear leads to increased grain yield.

Plant height had weak direct effect on grain yield. It is interesting that it had lower positive direct effect on grain yield than height to tassel base, which implicates that genotypes

with shorter tassels are more desirable in maize plant breeding. DUVICK (2005) reported a trend of decreasing of tassel length, in maize hybrids, over the years in commercial hybrids created over the years. Phenotypic changes may indicate improvements in efficiency of grain production (e.g., smaller tassels enable more energy for grain production). JANICK (2011) also concluded that ideal maize ideotype should have small tassel size. SALEEM *et al*., (2007) found weak positive genetic correlation between plant height and grain yield in irrigated conditions, while AHMAD and SALEEM (2003) reported significant and positive genotypic correlation between these traits, but the direct effect of plant height was negative and low. Opposite results were obtained by FILIPOVIC *et al., (2014),* who found strongest impact of plant height on grain yield.

Ear height had negative direct effect on grain yield. Genotypic coefficient correlation was also negative, and that score was obtained through indirect effect from ear height through all other traits, which were all negative. This is partially in accordance with SAIDAIAH *et al. ,*(2008) who reported negative direct, but positive genotypic correlation between the two traits. According to the research conducted by DUVICK (2005), ear height showed irregular trends toward reduction in height, but trends were weak.

Negative, but weak and direct effect of total number of leaves on grain yield, together with negative genotypic correlation, are opposite with results of MALIK *et al*., (2005) who found positive genetic correlation with grain yield per plant and total number of leaves.

Trait number of leaves above ear showed the highest values of all direct effects on grain yield, together with genetic correlation coefficient which was also the highest. SAIDAIAH *et al*., (2008) also found high direct effect between number of leaves above ear and grain yield, as well as high genotypic correlation between these traits.. According to these results on the studied genetic material, number of leaves above ear should be considered as one of the top priority traits in maize breeding programs.

It is interesting that simple correlation coefficients between ear height and total number of leaves had positive and significantly positive values with yield, while their direct effect with grain yield in path analysis was negative, discovering true nature between these traits. Such opposite results in values of these traits were also recorded by RAFIQ *et al*., (2010) and CARPICI and CELIK (2010).

Obtained results show that in modern maize breeding programs accent should be put on development of genetic material that creates hybrids characterised with shorter plant habitus, lower ear position and greater number of leaves above ear, which are photosynthetically more active.

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ANALIZA PUTANJE MORFOLOŠKIH OSOBINA KUKURUZA (*Zea mays* L.)

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Izvod

Šest samooplodnih linija kukuruza ukršteno je po metodu nepotpunog dialela. Na ovaj način dobijeno je petnaset hibridnih kombinacija koje su ispitivane u radu. Cilj istraživanja bio je da se procene direktni i indirektni uticaji pet morfoloških osobina na prinos zrna, primenom prostih korelacionoh koeficijenata, kao i analizom koeficijenata putanje. Najjači direktan pozitivan uticaj na prinos zrna imala je osobina broj listova iznad gornjeg klipa, sa 0.736. Pozitivan direktan efekat na prinos zrna su imale i osobine visina do osnove metlice i visina biljke, dok su negativni direktni efekti zabeleženi za osobine visina klipa i ukupan broj listova. Od indirektnih uticaja, izdvaja se pozitivan efekat visine položaja klipa na prinos preko ukupne visine biljke do vrha metlice. Ocena proporcije zajedničkog delovanja pet ispitivanih morfoloških osobina na prinos zrna, izražena koeficijentom determinacije (R^2_{y12345}) je iznosila 0.7881.

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