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Investigation of Correlation between Traits and Path Analysis of Corn (*Zea mays* L.) Grain Yield at the Climate of Ardabil Region (Northwest Iran)

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Abstract

In order to study correlation between some traits and yield components of corn and to determine the most effective factors on its yield, an experiment was conducted at the agricultural research farm of university of Mohaghegh Ardabili in 2007. The experiment was conducted as a split plot in a randomized complete block design with four replications. Main plots were allocated at three levels to different planting dates (10, 20 May and 30 June) and subplots were allocated at the different levels of nitrogen fertilizer (0, 75, 150, 225 Kg N ha-1). The utilized corn seed was SC 404 hybrid. Sequential path analysis was used for evaluation of relationships between yield and yield attributes and to eliminate less important variables by using SPSS. Results showed that kernel per ear has the most correlation ($r = 0.53$) with grain yield. The grain yield and kernel per ear indicated negative and significant correlation with grain thickness ($r = -0.33$ and $r = -0.52$ respectively). The correlation between grain protein and thickness was negative and significant, too ($r = -0.52$). Results obtained from path analysis revealed that kernel per ear has more importance for selecting corn cultivars with high yield among different traits. Kernel per row and grain length had an effect on grain yield. Thus, these two traits can be attend in breeding programs and also be effective as a potential traits in improving desired corn cultivars.

Key words: corn, correlation coefficients, path analysis, yield components

Introduction

Maize crop plays an important role in the world economy and is valuable ingredient in manufactured items that affect a large proportion of the world population (Alvi *et al*., 2003). Correlation studied between yield and yield components and between yield components themselves is a prerequisite to plan a meaningful breeding program (Ahmad and Saleem, 2003). Path analysis has recently been studied in some crop by Carvalho *et al*. (2002), Barbaro *et al*. (2006), Alvi *et al*. (2003) and Asghari-Zakaria *et al*. (2007).

Several workers have attempted to determine linkage between the characters on which the selection for high yield can be made. Annapurna *et al*. (1998) found that seed yield was positively and significantly correlated with plant height, ear diameter, number of seed row-1 and number of rows ear-1. You *et al*. (1998) reported significant correlations between yield and number of rows ear-1, number of grains row-1 and 1000-grain weight and also number of grains row-1 and number of rows ear-1. Khatun *et al*. (1999) studied that grain yield plant-1 was positively and significantly correlated with 1000-grain weight, number of kernels ear-1, ear weight and ear insertion height. Orlyan *et al*. (1999) studied that most important traits influencing grain yield are number of grains row-1 and number of grain cob-1. Characters like number of grains row-1, 1000-grain weight, cob diameter and plant height are also be useful in improving grain yield in hybrids. Maximum correlation of grain yield was obtained with number of kernels row-1 followed by plant height and cob length (Gautam *et al*., 1999). Cantarero (2000) found that late sowing reduced number of ears plant-1, number of grains ear-1 and grain yield.

The direct and indirect effects of different quantitative traits on grain yield were studied in 90 hybrids by Geetha and Jayaraman (2000) and they reported that number of grains per row exerted a maximum direct effect on grain yield. Hence, selection of number of grains per row will be highly effective for improvement of grain yield. Kumar and Kumar (2000) put emphasis on plant height with greater ear weight, number of seed rows per ear and number of seeds per ear for better grain yield. Mohammadi *et al*., (2003) reported that 100-grain weight and total number of kernels per ear revealed highest direct effects on total grain weight ($p = 0.74$ and $p = 0.78$, respectively), while ear length, ear diameter, number of kernel rows, and number of kernels per row were found to fit as second-order variables. Manivannan (1998) found that ear diameter, kernel rows, 1000-grain weight, kernel row-1 and ear length had significant correlation with seed yield. Mani *et al*. (1999) studied that grain yield plant^{-1} indicated highly significant positive correlation with all the other attributes. Devi, *et al*. (2001) reported that ear length, number of seed rows ear-1, number of seeds row^{-1} and 100-seed weight positively influenced the yield directly and also indirectly through several components.

A review of the works of other researchers indicates that determining relationships between yield and its components has special importance. Although the results of all experiments were not in agreement with each other, but in the most experiments some yield components such as 100–kernel weight, kernel per row and kernel per ear has big importance in determining yield. Thus, by determining reaction of corn grain yield under nitrogen levels at different planting dates, and recognition of the traits that has significant effect on yield, we can obtain great success in better programming of Agronomy management and breeding of progressive hybrids.

Our objectives were to determine the usefulness of a sequential path model relative to the conventional path model, and to analyze the associations between grain yield and related characters in maize by applying the model to different datasets, with special attention on the analysis of co-linearity of various predictor variables and analyzing the predictive value of the model.

Materials and methods

The field trial was conducted in 2007 at the Ardabil region (northwest Iran). The area is located at 38°19'N and 48°20'E at 1350 m altitude. The location of experiment by the view of atmosphere and climatic classification accounted as cold semi-arid area. The results obtained of experimental farm soil analysis showed that soil pH=8.12, EC=3.61 dsm-1 approximately, soil texture is loamy silt and the amounts of silt, clay and sand were 71, 5, 24 respectively. The experiment was conducted as a split plot in a randomized complete block design with four replications. Main plots were allocated at three levels to different planting dates (10, 20 May and 30 June) and sub plots were allocated at four different levels to nitrogen fertilizer (0, 75, 150, 225 Kg N ha-1). The utilized corn seed was the SC 404 hybrid. One third of nitrogen fertilizer was used after seedling emergence, and one third at 7 to 9 leaf stage and remained one third was used when male tassel emerged. Plots were irrigated with attention to the soil moisture and environmental conditions and through the growing season weed control was done by hand weeding and 2,4-D herbicide.

Along growing season recording and sampling were conducted to measure studied traits. Samplings were conducted from four internal rows and by considering boarder effect of each side of the rows. After harvesting ears from selected plants and separating grains from corn-cob, at first grains weighted and then the moisture percent of grains determined by hygrometer, and also yield according to 14% moisture content of grains was accounted by the following equation:

yield with 14%moisture = (yield with available moisture)×(100-percent of available moisture in grains)/(100-14)

In order to measure the yield components (kernel per ear, kernel per rows, and the number of rows per ear) and some traits such as cob weight and diameter, ear length, yield of each plant and harvest index, from main lines of each plot by regard the boarder effects, 8 competitive plants, random harvests and average of data was used for variance analysis. Also, percentage of grain protein was measured by seed analyzer model ZX-9500 (Zeltex, USA). In order to predict yield relationship and its components and also eliminating less important variations by sequential path analysis SPSS software (stepwise order) was used. At first, all measured traits as an independent variables and grain yield as a dependent variable, and the traits that had the most correlation whit grain yield were considered as first grade variables. In the next step grain yield was eliminated from model and one of the first grade traits was considered as an independent variable, and the traits that indicated the most correlation was considered as second grade variables. Other variables eliminated from models by this way, at the end other grades identified. After determining correlation coefficients and their direct and indirect effects, sequential path analysis diagram was drawn by AutoCAD software

Results and discussion

Simple correlation coefficients between studied traits illustrated in Tab. (1). Results showed that kernel per ear has the most positive correlation (r=0.53**) with grain yield. After this traits, the number of rows per ear and grain length showed the most correlation with grain yield (r=0.47** and r=0.49** respectively). The high correlation of grain yield with the number of rows per ear is reported by other researchers (Corke and Kannenberg, 1998; Mohammadi *et al*., 2003). Agrama (1996) reported that the number of rows per ear has the most great direct effect on grain yield. Increasing cob diameters caused an increase in the number of rows per ear and consequently increase in the number of rows per ear. In other words, grain yield with the cob diameters that caused the increase in kernel per ear, indicated positive and significant correlation. Consumption of 150 Kg nitrogen per hectare, by significant increasing of cob weight, increased kernel per ear and also increased grain yield significantly.

The grain yield and kernel per ear with grain thickness had negative significant correlation (r=-0.33** and r=-0.52**). It seems that by increasing kernel per ear, the grain thickness decreases and grain length increases. Grain length as pointed previously, had significant and positive correlation with grain yield.

Tab. 1. Correlation coefficients of studied traits in SC 404 Corn

GY	KT	KW	KL	1000KW	KWE	CW	CD	EL	KE	KR	RE	Trait
												RE
											-0.146	KR
										0.786**	0.490**	KE
									0.511**	0.582**	0.009	EL
								0.110	0.122	-0.244	0.585**	CD
							0.821**	0.289	0.039	-0.220	0.427**	CW
						0.794**	0.705**	0.332*	0.175	-0.094	0.444**	KWE
					0.729**	0.727**	0.587**	-0.100	-0.447**	-0.602**	0.162	1000KW
				0.694**	0.745**	0.715**	0.649**	0.039	0.036	-0.250	0.455**	KL
			0.458**	0.646**	0.426**	0.381**	0.256	-0.083	-0.411**	-0.321	-0.158	KW
		0.457**	0.043	0.470**	0.156	0.077	-0.005	-0.158	-0.527**	-0.472**	-0.203	KT
	-0.334*	0.032	0.476**	0.055	0.468**	0.397*	0.422*	0.317	0.531**	0.275	0.493**	GY
0.158	-0.526**	-0.436**	-0.127	-0.319	-0.180	-0.025	-0.114	0.300	0.377*	0.436**	-0.018	PRO

RE: row per ear, KR: kernel per row, KE: kernel per ear, EL: ear length, CD: cob diameter, CW: cob weight, KWE: kernel weight per ear, 1000KW: 1000-kernel weight, KL: kernel length, KW: kernel width, KT: kernel thickness, GY: grain yield, PRO: protein

*, ** significant at 5% and 1%, respectively

The correlation of grain protein percentage and grain thickness was negative and significant (r=-0.52**), in that more likely by increasing grain thickness, the density of starch grain in endosperm will increase and consequently the amount of protein will decrease. Between 1000-kernel weight and cob weight was positive and significant correlation (r=0.72**). It seems that by increasing cob weight due to more absorption of photo assimilates, the most portion of assimilates remobilizes to grains, so the grain weight will increase. To study relationships between yield and its components multiple regression analysis (sequential path analysis) was used. Grain yield as dependent variable was analyzed against other measured traits as independent variables and its results were illustrated in Fig. (1). Kernel per ear was a first rank variable in model, and explained 51 percent of variation in grain yield. Grain length was the second variable in first rank that controls 46 percent grain yield variation. The results showed that kernel per ear justify more than half of grain yield variation, and this may cover the other variables on grain yield. In the second stage, by eliminating grain length variable and grain yield among studied traits, kernel per ear entered in the model as a dependent variable and results are shown in Tab. (2). Kernel per ear as a first variable of second rank, explained

Tab. 2. Summery of sequential path analysis results and direct effect of variables on grain yield

Durbin-Watson	R2 Adj.	Direct effect	Independent variables	Dependent variables	Grade
2.02	0.46	0.51 0.46	KE KL	GY	1
1.95	0.99	0.87 0.63 -0.40	KR RE CW	KE	2
1.59	0.54	0.75	KWE	KL	2
1.99	0.62	-0.55 0.53	1000KW EL	KR	3
2.47	0.41	0.67 0.33	CD KW	RE	3
1.77	0.82	0.53 0.44 0.28	CD 1000KW EL	CW	3
1.33	0.74	0.57 0.35 0.33	1000KW EL CD	KWE	3
0.97	0.2	0.47	KT	1000KW	4
1.82	0.19	0.46	KT	KW	4
1.98	0.26	0.53	PRO	KT	5

RE: row per ear, KR: kernel per row, KE: kernel per ear, EL: ear length, CD: cob diameter, CW: cob weight, KWE: kernel weight per ear, 1000KW: 1000-kernek weight, KL: kernel length, KW: kernel width, KT: kernel thickness, GY: grain yield, PRO: protein

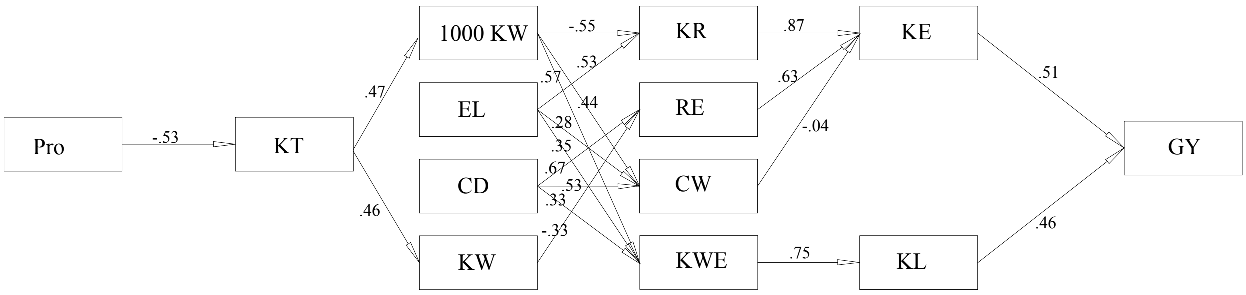

Fig. 1. Sequential path model illustrating interrelationships among various characters contributing to grain yield

RE: row per ear, KR: kernel per row, KE: kernel per ear, EL: ear length, CD: cob diameter, CW: cob weight, KWE: kernel weight per ear, 1000KW: 1000-kernel weight, KL: kernel length, KW: kernel width, KT: kernel thickness, GY: grain yield, PRO: protein

87 percent of kernel per ear variation solely. The number of rows per ear had direct and positive (0.63) effect on kernel per ear, but cob weight showed negative effect on this (-0.4). 1000-kernel weight did not show significant correlation with grain yield (Tab. 1). The cause of this is because of negative correlation of this trait with kernel per row and its negative direct effect (-0.55) on kernel per row, while kernel per row (0.087) directly had positive effect on kernel per ear.

Cob weight, in spite of its positive and significant correlation with grain yield, has direct negative effect on kernel per ear (Tab. 3). In fact, the most part of the correlation between cob weight and grain yield is the result of indirect effect of this trait by kernel per row and the number of rows per ear on grain yield.

1000-kernel weight had the most indirect effect by ear length on grain yield (Tab. 3). The most parts of correlations between cob diameter and grain yield is related to indirect effect on this trait of 1000-kernel weight. It was expected that accessibility to grain yield is more in early planting dates than late ones, because of long growing season and consequently increasing 1000-kernel weight, but the effect that force on grain yield by 1000-kernel weight, is very insignificant and negligible. Thus the most effect of this trait on yield is by kernel weight per ear. On the whole the results of path analysis showed that kernel per ear has more importance in selecting different traits of corn in yield. It is obvious that other variables will in the end have an effect on grain yield. The traits of kernel per row and grain length have more significant role on grain yield,

Tab. 3. Direct and indirect variables effect on grain yield

	Indirect effect by				
Total Correlation with grain yield		KL	KE	Direct effect	Variables
0.53**		0.017	-	0.51	KE
0.47**		-	0.018	0.46	KL
	CW	RE	KR		
0.27	-0.08	-0.09	-	0.78	KR
0.49**	0.17	-	-0.13	0.63	RE
0.39*	-	0.27	-0.19	-0.40	CW
		EL	1000KW		
0.05		0.37	-	-0.55	1000KW
0.32		-	-0.38	0.53	EL
		KW	CD		
0.42*		0.08	-	0.67	CD
0.03		-	0.17	0.33	KW
	EL	1000KW	CD		
0.42*	0.03	0.26	-	0.53	CD
0.05	-0.03	-	0.3	0.44	1000KW
0.31	-	-0.04	0.06	0.28	EL
	CD	EL	1000KW		
0.05	0.2	-0.03	-	0.57	1000KW
0.37	0.03	-	-0.06	0.35	EL
	-	0.03	0.33	0.33	CD

RE: row per ear, KR: kernel per row, KE: kernel per ear, EL: ear length, CD: cob diameter, CW: cob weight, KWE: kernel weight per ear, 1000KW: 1000-kernek weight, KL: kernel length, KW: kernel width, KT: kernel thickness, GY: grain yield, PRO: protein

198

so they must be considered in race developing to increase yield. Such results are reported by Agrama (1996).

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