CORRELATION AND PATH COEFFICIENT ANALYSIS FOR SOME EAR YIELD RELATED TRAITS IN POPCORN (*ZEA MAYS* VAR. EVERTA)

Erkan Ozata[1], Saime Unver Ikincikarakaya[2], Ahmet Ozturk[3]

[1] Karadeniz Agriculture Institute, Samsun, Turkey
[2] Ankara University Agriculture Faculty Field Crops Department, Ankara, Turkey
[3] Bati Akdeniz Agriculture Institute, Antalya, Turkey

Corresponding author: erkan.ozata@tarim.gov.tr

Abstract
The aim of this study is firstly to determine the suitable observations in popcorn breeding researches. And secondly aim is to identify all the possible interaction between grain yield and yield component in popcorn with correlation and path coefficient analysis. The experiments were designed in a randomized block design with 3 replicates. These experiments were conducted in Samsun, Turkey in 2014 and 2015. The results unveiled a significant and positive correlation between grain yield and the all component. The greatest positive effect on grain yield are yield per ear, grain yield per ear and grain moisture according to the path analysis, respectively. The presented results have demonstrated the potential of privileged of observation yield per ear, grain yield per ear and grain moisture thus increasing yield in popcorn.

Keywords: Popcorn, correlation, path analysis, yield, yield component.

Introduction

Corn (*Zea mays* L.) is one of the important cereal crops in the world after wheat and rice. Corn has become an indispensable product in cereals due to its use in human and animal feeding and industrial use. Popcorn (*Zea mays* everta) can be easily distinguished by plant and seed characteristics in other varieties groups. Corn is a product that can be preferred in terms of nutrition due to its rich nutritional content, vitamins and minerals it contains. Also, corn is a good dietary product with stomach acidic absorption properties, low calorie and whole grain corn intake by reducing the feeling of hunger and a good body weight control can be a good choice, unlike snack foods corn has low calorie and fat ratio, high carbohydrate ratio due to it has a special place among corn variety groups (Hansen, 2012; Ozkan, 2007; Ulger, 1998; Lilburn et al. 1994). The ability of the corn to explode and be used as a snack is the most important feature that distinguishes itself from other corn types. The production area and amount are increased in order to supply the increasing need of popcorn. Because popular culture behaviours increase the cinema and shopping mall in Turkey. Popcorn agriculture is made with contract in Turkey, as similar in the world. The popcorn cultivation area is approximately 10 thousand ha in Turkey. In recent years, corn cultivation area located in Elbistan, Cukurova (Adana-Mersin), Aydın, Denizli, Kayseri, Konya, Karaman and Kırşehir provinces (Ozturk, 2017). There are a few popcorn varieties registered and produced in Turkey. The varieties has a low yield potentials. Popcorn has an economic potential for farmers with the high yield varieties because of popcorn contracted production in Turkey. Studies are continued to develop high yields hybrid varieties resistant to disease and damages, which can be adapted to various ecological conditions in the modern corn breeding. Grain yield, which is the most interesting feature of plant breeding research, is a highly complex feature, which is the result of mutual interactions of the physiological and morphological characters in successive different phenological periods during vegetation of plants. The breeding of high yield genotypes depends on knowing how these characters are affecting yield and on identifying the causes of variation in grain yield for a given environment (Ozturk et al. 1999). It is not always possible to determine the interaction

between grain yield and yield factors in corn breeding studies only according to the correlation analysis. Since the interaction between any two variables may sometimes depend on a third variable, it may not be sufficient to explain the causal interaction between the yield and the yield components with the correlation coefficient (Okut et al. 1993). Independent of each other change in other one from two properties in a positive or negative way have on impact on yield causes decreasing or increasing changes in other property. There is opportunity determination like these indirect effects with correlation coefficient. For this reason, path coefficient analysis separates to direct and indirect effects correlation coefficient between yield and yield components. It supplies direct and indirect effect each of properties on yield, proportionality. Interaction of characters becomes more understandable and useable consequently more effective selection can occur. Studies conducted is different genotype and environment conditions for high productive of genotypes breeding in corn, response of identification a large number of properties interaction with grain yield, according to path analysis. It was determined that direct and indirect effects of number of grain, grain weight, yield per ear, weight yield per ear, was high and significant (Wright et al. 1934; Steynberg et al.1983; Sade, 1994). Also in many studies it was determined that grain moisture. Selection method is a widely used and successful method in plant breeding. Response to selection depends on many factors such as the interaction of the characters. Plant breeders work with some yield components related to yield in the selection programs. It is very important to determine relative importance of such characters contributing to grain yield directly or indirectly. Correlation and path coefficient analyses may assist to determine certain characters to be used in the improvement of the complex character such as yield. Information about correlative characters in popcorn has been still very limited. The direct and indirect effects of specific yield components might be precisely identified and applied in breeding programs of popcorn by determining of interaction among grain yield and yield components. Aim of this study is to determine yield components through correlation and path coefficient analyses. Thus results might be utilized by the breeders to develop new high yielding popcorn varieties.

Material and methods

The trial was arranged in the randomized completely block design with three replicates. It has 8 popcorn varieties under drop irrigated conditions during the 2014 and the 2015 main growing seasons. The experiment conducted on the location where Karadeniz Agriculture Institute in Carşamba, Samsun (Latitude 41°13' and Longitude 36 °40') is in the north part of Turkey near Black Sea with altitude of 3 m and dominated by the Blacksea climatically conditions. The experimental area has a heavy soil structure with clay-silt soil at 0-20 cm depth and clay-loamy structure at 20-40 cm depth. Standard agronomical practices were applied in both years. Each plot had three rows 5 m length with spacing 70 cm between rows and 18 cm between plants (Anonymous 2010). Two seeds were sowed in each hill and then thinned to one plant to have a final plant density of 71420 plants ha^{-1}. Seed harvest date was month in October. Observations and measurements including seven characters which tasselling, plant height, first ear height, weight per ear, grain weight per ear, grain moisture, grain/ ear ratio. Analysis of variance was performed for each character and LSD (least significant difference) test was applied to compare the differences (Steel and Torrie, 1980). Since genotype x year interaction was not significant for grain/ear ratio, mean values were obtained over two years. Phenotypic correlations were calculated and considering grain yield as a dependent variable, path coefficient analyses were carried out according to the procedures given by Dewey and Lu (1959).

Results and discussion

The analysis of variance revealed significant differences in all 8 quantitative characters and varieties (Table 1). This indicated the existence of sufficient variability among genotypes for all the characters studied except for grain/ear ratio. The chosen parents have diverse with a different genetic

background. The hybrid varieties were significant differences for measured traits in the p≤ 0.01 and 0.05 statistical level. Correlation among the traits may be the result of the genetic association among the characters. Interaction is very important which is between grain yield and its component traits for the breeders.

Table 1. Mean values of some agronomic characters of the hybrid popcorn varieties combined over two years

Varieties	Grain yield (kg/da)	Tasseling (day)	Plant length (cm)	First Ear height (cm)	Yield per ear (g)	Grain Yield Per ear (g)	Grain moisture (%)	Grain/ ear ratio (%)
Koçcin (st)	538,4 a	70,6 b	290 ab	111,6 b	132,8 ab	108,4	19,9 b	81,6
TCM 2012-2	521,2 a	71 b	270 b	146,6 a	124,4 b	102,9	21,6 a	82,7
TCM 2012-3	504,7 ab	73,3 a	315,6 a	146,6 a	127,4 b	106,1	20,3 b	83,2
TCM 2012-5	477,6b	69,3 b	275 b	101,6b	108,3 b	88,8	19 b	82,0
TCM 2012-4	437,0 bc	71,3 a	280 b	115 b	92,5 c	77,7	18,7 b	84,0
Antcin (st)	422,6 c	70,0 b	282,5 ab	133,3 a	106,8 b	90,0	21,3 a	84,3
TCM 2012-1	376,8 d	71,5 ab	225 d	118,3b	148,8 a	124,4	21,4 a	83,6
TCM 2012-6	372,9 d	72,0 ab	310 a	127,5 ab	154,2 a	127,5	20,2 b	82,7
VK (0.05)	14,7	2,91	6,21	6,42	5,52	5,87	3,24	7,45
LSD (%5)	50,2	3,54	29,1	22,2	12,8	10,4	2,48	--
Prob.	**	*	**	*	*	*	*	N.S.

Table 2. Correlation coefficients among the traits of eight popcorn varieties and profanities

	Grain weight	Tasseling	Plant length	First Ear height	Yield per ear (g)	Grain Yield Per ear (g)	Grain moisture	Grain/ ear ratio
Grain yield	1,00	0,067	0,272	0,218	0,565*	0,382	0,072	-0,254
Tasseling		1,00	0,013	-0,113	-0,030	0,003	-0,010	0,241
Plant height			1,00	0,724**	0,140	0,066	0,266	-0,336
First Ear height				1,00	0,279	0,229	0,174	-0,130
Ear weight					1,00	0,986**	-0,220	0,322
Ear grain weight						1,00	-0,224	0,473*
Grain moisture							1,00	-0,053
Grain/ ear ratio								1,00

Table 2 indicates that the correlation coefficients among traits. The most important correlation was between weight per ear and grain weight per ear (r = 0.986**). The r values indicated that ear weight and had the highest positive correlation (r=0.565*) with grain yield. Phenotypic and genotypic correlations were worked out on yield and yield contributing characters and are presented in Table 2. Genotypic correlations has a higher value than the corresponding phenotypic values. It was estimated that there was strong inherent interactions between studied characters. Its expression was reduced due to the influence of environment. Plant length was found that positively correlated with first ear height. Hence selection for these characters would improve the yield. Similar results were reported by Sridhar (2016), Natarajet al. (2014), Vijayabharathi et al. (2009), Kumar and Sathyanarayana (2001) Sharma and Kumar (1987), Hua et al . (2004) and Kumar et al. (2007). Grain yield, which is accepted as a major economic character in corn and due to its complex nature depends on all other yield components. Change in anyone of the components may ultimately affect the yields. Hence, these correlated traits have to be analysed for direct and indirect effects over other yield components on the grain yield (Kumar et al., 2011). Therefore, the total correlations

were analysed how partitioned in to the direct and the indirect effects. Path analysis were used for grain yield per plant as dependent variable. Path analysis revealed that grain yield has an interaction all independent variables. This analysis also allows separate between direct effect and their indirect effects. This partitioned correlation might help to selection criteria for popcorn breeders. The results are presented as amount and percentage in Table 3, respectively.

Table 3. Direct and indirect effects of different traits on grain yield of popcorn path coefficient (amount)

Traits	Direc effect	Tasseling	Plant height	First Ear height	Yield per ear	Grain yield per ear	Grain moisture	Grain/ ear ratio
Traits	0,184		-0,0005	0,006	0,089	-0,007	-0,002	-0,024
Tasselling	-0,035	0,002		-0,039	0,422	-0,163	0,051	0,033
Plant height	-0,054	-0,020	-0,026		0,841	-0,569	0,033	0,131
First ear height	3,011	-0,005	-0,005	-0,153		-2,445	-0,043	-0,032
Yield per ear	-2,480	0,0005	-0,024	-0,012	2,968		-0,043	-0,047
Grain yield per ear	0,195	-0,001	-0,009	-0,009	-0,66	0,555		0,0054
Grain moisture	-0,101	0,044	0,0120	0,0071	0,968	-1,174	-0,010	
Grain/ ear ratio								

Table 4. Direct and indirect effects of different traits on grain yield of popcorn path percentage (%)

Traits	Direct Effect	Tasseling	Plant height	First Ear height	Yield per ear	Grain yield per ear	Grain moisture	Grain/ ear ratio
Tasselling	58,66		0,14	1,98	28,62	2,24	0,60	7,74
Plant height	4,78	0,313		5,30	56,39	21,76	6,92	4,52
First ear height	3,51	1,33	1,66		53,96	36,49	2,17	0,84
Yield per ear	54,18	0,09	0,009	0,27		43,99	0,77	0,58
Grain yield per ear	44,64	0,00	0,042	0,22	53,42		0,78	0,86
Grain moisture	13,54	0,12	0,66	0,66	46,06	38,56		0,37
Grain/ ear ratio	4,35	1,91	0,51	0,30	41,78	50,66	0,44	

Path analysis revealed that highest positive contribution on grain yield are tasselling (58,7%), weight per ear (54,2%), grain weight per ear (44,6%) and grain moisture (13,5%). In addition that the other traits give low positive direct effect grain yield. Thus these traits could be used more confidently as the selection criteria in the grain yield of popcorn. The present results can be comparable with the results of Sridhar (2016) and (Kumar, et al 2007).

Conclusions

It was revealed that grain yield is positively correlated with ear length, yield per ear, grain moisture, tasselling, plant length, but negative associated with grain/ear ratio. Path coefficient analysis revealed that ear length is the largest positive direct effect on grain yield per plant followed by yield per ear, grain yield per and grain moisture. In conclusion, yield per ear might be used as a selection criteria due to its highly positive direct effect as well as indirect effects on all other characters on grain yield. Also grain yield per ear and ear moisture may be considered as yield component as selection criteria in popcorn breeding. Hence direct selection for these traits might be effective.

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References

1. Bhatt, G. M., 1973. Significance of path coefficient analysis in determining the nature of character association. Euphytica 22: 338-343, 1973.

2. Dewey, D.R., K.H. Lu, 1959. A correlation and path analysis of components of crested wheat grass seed production. Agron . J. 51: 515-518.
3. Dofing, S.M., Croz-Mason, N.D. and Compton, M. A. T. (1991). Inheritance of expansion volume and yield in two popcorn x dent corn crosses. Crop Science. 31, 715-718. 4.
4. Farhatullah. (1990). Correlated response of maize grain yield with yield contributing traits. Sarhad Journal of Agriculture, Pakistan. 6, 445-457. 5.
5. Gravois, K. A., Helms, R. S., 1992. Path analysis of rice yield and yield components as affected by seeding rate, Agron. J., 84, 1-4, 1992.
6. Hansen, R., 2012. Popcorn Profili, a national information resource for value-added agriculture.2012.
7. Hua, T., Yiqin, H., Yas-ajianbing and Yonglian, Z. (2004). Genetic analysis of yield traits with elite maize hybrid - Yuyu 22. Acta Agronomica-Sinica. 30, 922-926. 6.
8. Jibouri, H.A., Miller, P.A. & Robinson, H.F. (1958). Genotypic and environment variances in an upland cotton crops of interspecific origin. Agronomy Journal. 50, 633-634. 2.
9. Joshi, B.K, 2005. Correlation, regression and path coefficient analyses for some yield components in common and Tartary buckwheat in Nepal. Fagopyrum 22: 77-82.
10. Kumar, J., Sundaram, T., Prabu, D.A and Rajan, A.R.R. (2007). Correlation studies in maize evaluated for grain yield and other yield attributes. International Journal of Agricultural Sciences. 3, 57-60. 7.
11. Lilburn, M. S., 1994. Research Note: The Use of Popcorn in Dietsfor Growing, Turkeys. Maize Abstracts, January 1994, Volume: 10, No: 1, p.83.1994.
12. Nguyen, V., Cooper, L., Lowndes, J., Melanson, K., Angelopulos, T.J., Rippe, J.M. and Reimers, K., 2012. Popcorn is more satiating than potato chips in normal-weight adults, Nutrition Journal, 11-71, 1-6.2012.
13. 0kut, H., Orhan, H., 1993. Korelasyon katsayısı ve path analizi, I. Ulusal Ekonometri ve istatistik Sempozyumu, 11 12 Kasım 1993, Ege Un., İzmir, 1993.
14. Özkan A. 2007. Çukurova koşullarında değişik azot dozu uygulamalarının iki cin mısırı (*zea mays everta* Sturt.) çeşidinde tane verimi, tarımsal özellikler ve bazı kalite özelliklerine etkisi, Ç.Ü Fen Bilimleri Enstitüsü, Doktora Tezi..
15. Öztürk, A., Akten, 1999. Kışlık buğdayda bazı morfolojik karakterler ve tane verimine etkileri, Türk Tarım ve Ormancılık Dergisi, 23 (Ek Say1 2), 409-422, 1999.
16. Öztürk. A., Erdal, Ş., Pamukçu, M., ve Özata, E., 2017. Türkiye'de Özel Mısır Tiplerinin Kullanımı ve Geleceği Intanrantional conference on Agriculture, Forest, Food, Science Tecnologies, 15-17 May 2017. Nevşehir, Turkey
17. Patil, S.J., Hayavadan, P.V., Mahadevappa, M. (1969). Interrelationship between grain yield, ear height and internode characters in Zea mays (L.). The Mysore Journal of Agricultural Sciences. 3, 272-276. 8.
18. Pordesimo, L. O., Anantheswaran, R. C., Fleishmann, A. M., Lin, Y. E., Hanna, M A. (1990). Physical properties as indicators of popping characteristics of microwave popcorn. Journal of Food Science. 55, 1352-1355. 9.
19. Reddy, V. S., Chandra Mohan, Y., Rao, N.V., Krishna, L., (2003). Character association and path analysis in popcorn. (Zea mays var. everta). Crop Research. 25(2), 297-300
20. Sade, B., 1994. Melez mısır çeşitlerinde (Zea mays L. indentata) Tane verimi ve bazı komponentlerinin korelasyonu ve path analizi, Selcuk U. Z. F. Dergisi, 7, 28-39, 1994.
21. Selvaraj, C.I., Nagarajan, P. (2011). Interrelationship and path-coefficient studies for qualitative traits, grain yield and other yield attributes among maize (Zea mays L.). International Journal of Plant Breeding and Genetics. 5(3), 209-223. 11.
22. Sharma, R.K., Kumar, S. (1987). Association analysis for grain yield and some quantitative traits in popcorn. Crop improvement. 14(2), 201-204. 12.

23. Song, A., Eckhoff, S.R., Paulsen, M., Litchfield, J .B., 1991. Effects of kernel size and genotype on popcorn popping volume and number of unpoped kernels. Cereal Chemistry. 68(5), 464-467. 13.
24. Srıdhar M., Krıshna K. Muralı, Sultana Razıa and Bhave M.H.V. 2016. Character associatıon and path analysıs for graın and yıeld component traıts ın popcorn. International Journal of Agrıculturel Science and Research ISSN (E):2321-0087 Vol 6 Issue 6 December 2016 p 145-150.
25. Steynberg, R. E., Nel, P. C., Hammer, P. S., 1983. The influence of fertilization on certain yield components of maize in long- term fertilizer experiment, Maize Abstract, 1, 27, 1983.
26. Ülger AC. 1998. Farklı azot dozu ve sıra üzeri mesafelerinin patlak mısırda (*Zea mays everta* Sturt.) tane verimi ve bazı tarımsal özelliklere etkisi; Çukurova Üniversitesi Ziraat Fakültesi Dergisi, 13 (1): 155-164.1998
27. Wright, S., 1934. The method of path coefficients, Ann. Math. Stats., 5, 614-617, 1934
28. Wright, S., 1921. Correlation and Causation. Journal of Agricultural Research. 20, 557-585
29. Vijayabharathi, A., Anandakumar, C.R., Gnanamalar, R.P., 2009. Analysis of correlations and path effects for popping expansion in popcorn. (Zea mays var. everta Sturt.). Electronic journal of plant breeding. 1, 60-64