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Original Article

Variation in Agro-morphological Traits of Some Turkish Local Pop, Flint and Dent Maize (*Zea mays* L.)

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Abstract

Turkish maize accessions collected from north of Turkey were investigated for agro-morphologic variation in three maize kernel types (flint, pop and dent) including 79 accessions. Eight agronomic and morphologic traits (ear length, ear kernel row number, ear height, leaf number, 1000 kernel weight, tassel length, leaf width and leaf length) were analysed by ANOVA and principal component analysis. Varieties and accessions were found significantly different for variance components which were made up high variance due to accessions. Positive correlations were found between agronomic and morphologic traits. Multivariate discriminant function analysis with eight traits revealed that first two of multivariate correlation covered 86.6%, and next 69% of total variation among accessions and the first multivariate discriminant function had high eigenvalue with 76.8% of total variance between varieties belonged to flint and pop maize accessions while the second multivariate variable belonged to flint and dent maize accessions. These multivariate variables correctly classify three maize varieties maintaining maize accessions for their various characteristics with agronomic and morphological traits.

Keywords: agronomic traits; maize genotypes; principal component analysis; Turkish maize accessions

Introduction

Contrary to the fact that maize consists of about 12.000 accessions and representing 256 varieties (Machado *et al*., 1998), only two percent of maize germplasm is used in maize breeding programs (Carvalho *et al*., 2004). Most of the present agro-morphological traits are still conserved traditionally by small farmers (Marshall, 1977); further available mixed cultivars in continental America displaying dent, flint and floury forms with different colors can be used in maize improvement (Paterniani, 2000; Abadie *et al*., 2000). The genetic variability among influential distinction provides a capable selection. The size of the genetic variability found in the population is of great importance for the success of any plant breeding program (Mohamed *et al*., 2012).

Following the introduction of maize to Anatolia by ottoman traders (1600 A.D.), its production usage was limited to small areas with traditional farming practices until the 1950s (Kün, 1994). There are three types of maize in Turkey that are flint maize, dent maize, and pop maize. Although flint maize is mainly planted in the Black Sea Region; dent maize, mostly planted at Aegean and Marmara Regions and even pop maize is planted in whole Turkey (Ilarslan *et al*., 2002). Harlan (1951) created maize collections from maize genotypes collected from Turkey and he observed that Turkish maize genotypes display heterogeneous variation.

Ilarslan *et al*. (2001) investigated the genetic composition of Turkish maize varieties using 19 isoenzyme markers for agronomic traits by sampling thirty-two maize accessions representing climatic, geographic and topographic regions of Turkey from the collections of USDA/ARS North Central Regional Plant Introduction Station (NCRPIS), Ames, Iowa. Ilarslan *et al*. (2002) suggested that there is a large amount of genetic variation exists in the maize varieties and accessions of Turkey and they may have lost their original genetic resources because of the changing in agricultural practices with high yielding genetic lines.

Morphological characterization is the first step in the identification and categorization of the genetic resources (Smith *et al*., 1990). Enough knowledge is needed on the importance of vital biological events and genetic diversity in plants for the effective protection, management and use of plant genetic resources (Iqbal *et al*., 2014). Agronomic and morphologic traits have large valuable information for breeding and conservation. Although there is a paper on the utilization of Turkish maize variety and accessions in Anatolia done by Ilarslan *et al*. (2002), it belongs to the seeds of maize collected by Harlan (1951) in 1948. The aim

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of this study is to utilize the genetic variation in terms of varieties and accessions of maize at the north of Anatolia using agronomic and morphologic traits by ANOVA and the principal component analysis of accessions and varieties comparing the study done by Ilarslan *et al*. (2002).

Materials and Methods

The accessions of seventy-nine germplasm were collected from different location and altitude of North of Turkey (Table 1).

These accessions were evaluated in the field during summer 2015 at the Agricultural Faculty of Ordu University, The City of Ordu, Turkey (altitude: 24 m). The accessions were planted on May 15 in single-row-plots (30 plants per row) in a randomized block design. The measurements were done randomly on selected 6 individual plants in each row exceptional the edge rows. Row space was 0.70 m and within-row plant spacing was 0.20 m. Various classification was done using eight traits, which are the most heritable and discriminatory agronomic and morphologic traits reported by several researchers (Sánchez *et al*., 1993; Revilla and Tracy, 1995; González Ugalde, 1997; Iqbal *et al*., 2015). These variables were utilized also by Ilarslan *et al*. (2002) in 32 Turkish accessions measuring directly. The traits were utilized in centimetre by counts and as rations from measurements (Table 1). Agro-morphological properties were assessed according to the properties set forth in IBPGR (IBPGR, 1991). Eight quantitative traits, namely, number of rows per ear (NRE, number of kernel rows around the cob at 5 cm from the shank of uppermost ear), ear height (EH, lenght of stem in cm from soil level), leaf number per plant (LN, calculated as number or leafs number of plants), 1000 kernel weight (TKW, mass of 1000 kernels in g adjusted to 18% moisture content), tassel lenght (TL, lenght is cm of tassel from flag leaf to tassel type), leaf width and leaf lenght (LW and LL, width and lenght in cm, respectively, of leaf which under the ear per plant). The data were standardized calculating means and standard deviation for each trait within 79 accessions (Asare *et al*., 2016; Mitrović *et al*., 2016; Bouchet *et al*., 2017; Gazal *et al*., 2017).

ANOVA was used to analyze the significant differences among the accessions. Trait means were calculated for each maize accession. Data correlation matrix was constructed from the mean values and it was used in the principal component analysis to classify the 79 Turkish maize accessions. All statistical analyses were conducted with Statistical Software Package SPSS, 22 (IBM Corp. Released, 2013).

Table 1. Accession number, location of accessions, kernel type, and altitude of maize accessions

Acces. No	Location	Kernel Type	Altitude	Acces. No	Location	Kernel Type	Altitude
1	Samsun	Flint	32	41	Samsun	Flint	54
2	Samsun	Flint	45	42	Samsun	Flint	47
3	Samsun	Flint	30	43	Ordu	Flint	243
4	Samsun	Flint	48	44	Samsun	Flint	39
5	Samsun	Flint	23	45	Samsun	Flint	46
6	Samsun	Flint	55	46	Samsun	Flint	47
7	Tokat	Flint	520	47	Samsun	Flint	51
8	Tokat	Flint	618	48	Samsun	Flint	52
9	Tokat	Flint	581	49	Samsun	Flint	55
10	Trabzon	Flint	420	50	Ordu	Flint	234
11	Trabzon	Flint	250	51	Samsun	Flint	55
12	Rize	Flint	280	52	Ordu	Dent	229
13	Samsun	Flint	35	53	Ordu	Dent	244
14	Rize	Flint	678	54	Samsun	Dent	50
15	Samsun	Flint	39	55	Zonguldak	Flint	500
16	Çorum	Flint	467	56	Zonguldak	Flint	521
17	Ordu	Flint	125	57	Artvin	Flint	1500
18	Karabük	Flint	345	58	Samsun	Flint	55
19	Samsun	Flint	605	59	Giresun	Flint	1000
20	Giresun	Flint	818	60	Trabzon	Flint	155
21	Samsun	Flint	35	61	Karabük	Popcorn	800
22	Samsun	Flint	35	62	Karabük	Popcorn	800
23	Samsun	Flint	35	63	Samsun	Popcorn	67
24	Artvin	Flint	1210	64	Samsun	Popcorn	56
25	Ordu	Flint	365	65	Samsun	Popcorn	34
26	Samsun	Flint	68	66	Samsun	Popcorn	34
27	Karabük	Flint	350	67	Tokat	Popcorn	903
28	Samsun	Flint	35	68	Trabzon	Popcorn	874
29	Samsun	Flint	44	69	Çorum	Popcorn	250
30	Trabzon	Flint	235	70	Trabzon	Popcorn	200
31	Ordu	Flint	130	71	Çanakkale	Popcorn	600
32	Samsun	Flint	46	72	Çanakkale	Popcorn	600
33	Samsun	Flint	43	73	Çanakkale	Popcorn	600
34	Samsun	Flint	120	74	Çanakkale	Popcorn	345
35	Samsun	Flint	112	75	Çanakkale	Popcorn	600
36	Trabzon	Flint	150	76	Çanakkale	Popcorn	600
37	Trabzon	Flint	165	77	Bursa	Popcorn	450
38	Samsun	Flint	29	78	Çanakkale	Popcorn	678
39	Trabzon	Flint	163	79	Bingöl	Popcorn	800
40	Samsun	Flint	45				

Results and Discussion

The ANOVA analysis showed that there were significant differences between the agronomic and morphological traits among maize varieties and accessions (Table 2). As the mean and standard deviation indicated that the particularly studied traits had higher values in dent varieties than other two varieties (Table 2a). The accessions within varieties also showed a significant variation for all traits. The similar results were obtained in a Turkish accession study by Ilarslan *et al*. (2002) the studied traits have been reported in the literature that they are highly heritable traits (Sanchez and Goodman, 1992; Sánchez *et al*., 1993; Revilla and Tracy, 1995; Mohammadi and Prasanna, 2003; Hugues *et al*., 2015). The high variance due to the within varieties indicates that accessions can have already utilized as" landraces" as a result of farmer's selection for many years (Ilarslan *et al*., 2002). Ilarslan *et al*. (2002) reported that most of the dent accessions came from the coastal regions where the growing season is longer and had the mild climate. Other two varieties (flint and pop maize) come from either coastal or inland region with a large of variation for growing season but mostly short. Farmers prefer flint and pop maize varieties because of the intense usage of them for human food in the coastal region and time-earning from the growing season for other alternative plants for winter. These three varieties can be classified due to their seed morphology such as kernel type.

The correlation between agronomic and morphologic traits was found as significant. For instance, ear height trait and other traits; leaf number, 1000-kernel weight, tassel length, leaf width, respectively, were correlated and positively significantly as 0.496, 0.239, 0.534, 0.312 and 0.553. It has been observed a strong correlation between the 1000-kernel weight and leaf dimension traits (Table 3) except for tassel length trait. Negative correlations were found among the ear kernel row number and 1000-kernel weight, tassel length, leaf width, leaf length traits. This type of correlation between traits may result from the collection of many practiced in the study region. Turkish farmers usually collect seeds from former plants having better growth forms, morphological and agronomical, but there is no any selection procedure. The used seeds by farmers in the following year are limited to randomly bulked seed collections of the previous year. Maize is a cross pollinated species and although selection there is no isolation for maize plantations and flint and pop maize plants are grown in the same plantations in most of the farms. The seeds used in this study were collected from high and low altitude farms. Hybrid plants are preferred by low altitude farm owners allowing gene flow between growth plantations until 200 m (Luna *et al*., 2001). The negative correlation could be explained by the resource allocation.

The Fisher's linear discriminant functions and classification function coefficients showed that the most important traits in the classification are number of per ear (number), 1000-kernel weight (g), tassel length (cm), leaf width (cm) and leaf length (cm), respectively (Table 4). Their classification function coefficients are given due to genotypes in Table 3. The preferable trait was found to be ear kernel row number for further studies.

Eight agronomic and morphologic traits were treated principal component analysis. The results showed that first two multivariate correlations covered 86.6% and second, 69% of the total variation among accessions. The first principal component function had high eigenvalue (76.8% of the total variance between varieties) belonged to flint and pop maize accessions while the second multivariate variable belonged to flint and dent maize accessions (Table 4). These results showed that north Turkish maize accessions classified for their racial characteristics, which were grouped as flint, pop and dent maize accessions from the angle of seed collection and agronomic and morphologic traits by principal component analysis. Accessions 17 and 71 were considered as flint maize and accession 5 was considered pop maize before the analysis as misclassified (Fig. 1). The results of this present study are quite like the results obtained for the classification of maize varieties by Ilarslan *et al*. (2002). However, there was no relationship between pop and flint maize varieties the studied by enzyme polymorphism (Ilarslan *et al*., 2001) but the same study suggested that there could be a gene flow between flint and pop maize varieties.

The cross sections of the centroid of multivariate discriminant function in Fig. 1 showed that the centre of accessions is Ordu location.

Table 2. Mean squares of analysis for some agronomic-morphological traits among 79 local maize genotypes

S.O.V.	df	EKN	EH	LN	TKW	TL	LW	LL
Kernel Types	2	66.92**	3969.56**	6.53	125972.5**	185.61*	2.28*	458.85*
Genotypes	76	7.54	1167.82	2.39	4873.7	48.62	0.72	104.70
Total	78							
CV		25.79	39.34	12.90	33.04	18.81	12.80	15.23

Note: S.O.V.- Source variation, df- degree of freedom, *: significant p<0.05, **: significant p<0.01. ns: Non-significant. EL; Ear length (mm), EKN; Ear kernel row number, EH; Ear height (mm), LN; Leaf number (number), TKW; 1000-kernel weight (g), TL; Tassel length (mm), LW; Leaf width (cm), LL; Leaf length (cm).

Table 2a. Descriptive statistics for maize varieties (flint, pop and dent corn) like mean and standard deviation and Duncan group

Kernel Types	N	EKN ± Std	EH ± Std	LN	TKW	TL	LW	LL
Flint	59	11.11 ± 2.8 b	88.71 ± 35.6 b	12.15 ± 1.55	298.23 ± 72.6 a	38.45 ± 7.5 b	6.82 ± 0.83 b	69.89 ± 10.05 b
Popcorn	16	14.37 ± 2.5 a	81.87 ± 29.31 b	12.12 ± 1.54	158.37 ± 61.4 b	36.00 ± 4.8 b	6.50 ± 0.93 b	67.14 ± 11.53 b
Dent	4	11.50 ± 1.9 b	131.25 ± 27.8 a	14.00 ± 1.41	307.25 ± 50.8 a	46.75 ± 4.7 a	7.68 ± 0.71 a	84.02 ± 5.72 a
Total	79	11.79 ± 3.01	89.48 ± 35.20	12.24 ± 1.57	270.36 ± 89.3	38.37 ± 7.22	6.81 ± 0.87	70.05 ± 10.66

Std: Standard Deviation

Table 3. Correlation coefficients between agronomic and morphologic traits

Traits	EL	NRE	EH	LN	TKW	TL	LD
NRE	0.187						
EH	0.342**	-0.102					
LN	0.272**	0.086	0.476**				
TKW	0.291**	-0.645**	0.204	0.038			
TL	0.298**	-0.099	0.524**	0.165	0.178		
LW	0.186	-0.246*	0.402**	0.348**	0.220	0.309**	
LL	0.250*	-0.263*	0.560**	0.386**	0.288*	0.415**	0.800**

*: significant p<0.05. **: significant p<0.01. EL = Ear length (cm), NRE = number of rows per ear; EH = Ear height (cm), LN = Leaf number per plant (number), TKW = 1000-kernel weight (g), TL = Tassel length (cm), LW = Leaf width (cm), LL =Leaf length (cm).

Table 4. Fisher's linear discriminant functions and classification function coefficients

Traits	Kernel Types		
	Flint (1)	Popcorn (2)	Dent (3)
NRE	0.138	0.148	0.170
TKW	0.078	0.061	0.090
TL	0.034	0.077	0.077
LW	0.113	0.106	0.067
LL	-0.027	-0.042	0.016
(Constant)	-91.269	-101.831	-140.259

NRE; Ear kernel row number, TKW; 1000-kernel weight (g), TL; Tassel length (cm), LD; Leaf width (cm), LL; Leaf length (cm).

Table 5. Principal components analysis of 79 Turkish local genotypes evaluated in Ordu in 2015 using 8 agro-morphological traits

Trait	PC 1	PC 2
Ear length(cm)	0.738	0.351
Ear kernel row number (number)	0.388	-0.019
Ear height (cm)	-0.130	0.698
Leaf number (number)	-0.279	0.625
1000-kernel weight (g)	0.137	0.464
Tassel length (cm)	0.169	0.357
Leaf width (cm)	-0.229	0.310
Leaf length (cm)	0.091	0.133
Eigenvalues	3.009	0.910
Multivariate Correlation	0.866	0.690
Variance (%)	76.8	23.2

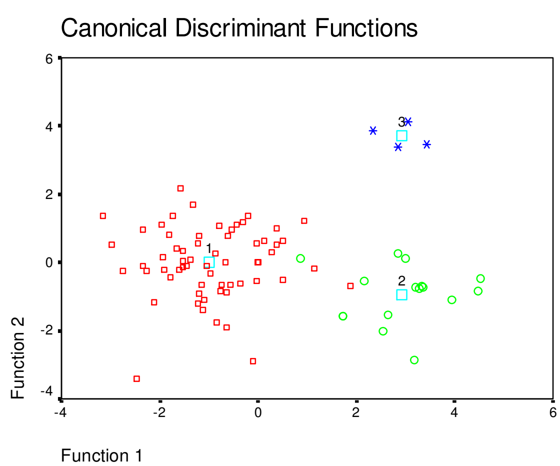

Fig. 1. The grouping of Turkish maize accessions based on multivariate discriminant function analysis for agro-morphological traits. Maize genotypes were displayed as Flint(1), Popcorn(2), and Dent (3)

Conclusions

The study indicates that maize accession collected from north of Turkey in 2010-2014 maintain considerable genetic variation in agronomic and morphologic traits at the level of either varieties or accessions. Further, Turkish seed collections are also available in NCRPIS. Ames. The USA collected local maize seeds in 1948-1952. If the results of this study compared with accessions (32 accessions) collected between 1948-1952 and 2015 years for the genetic composition of maize genetic resources of Turkey (Ilarslan *et al.*, 2002), it seems that there is a higher variation between research years (68% for 1948-1952 and 86.6% for 2015). The reason for this may come from the study area which is the north part of Turkey and most of the genotypes belong to flint type accessions. Breeder wants the variation to be high in order to be able to work from the genetic pool in breeding programs. If the breeder develops a silage corn, the number of leaves per plant and the size and width of the leaf are important criteria. For this reason, it makes the selection according to the parameters desired from the pool. In addition, because the areas where our work is done are very small, and in these areas, the farmers are protected by this material because of the aging of the planting areas and the loss of the young population. In addition to this suggestion, an introduction of high yielding genetic lines may increase the genetic variation. This study displays an informative knowledge of populations between years and preferable trait for selection to understand the background of accessions in following generations having a high adaptive capacity for the region and selection effect of farmers for the conservation of maize genetic resources.

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