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Morpho-physiological Traits and Mineral Composition on Local Maize Population Growing in Agro Ecological Conditions in Kosova

Sali ALIU[1], Imer RUSINOVCI[1], Shukri FETAHU[1], Kemajl BISILIMI[2]

[1]*The University of Prishtina, Faculty of Agriculture and Veterinary, Department of Crop Science, 'Bill Clinton' St., N.N. Prishtina, Kosovo; salialiu02@gmail.com (*corresponding author)*

[2]*University of Prishtina, Faculty of Natural Science, Department of Biology, Prishtina, Kosovo*

Abstract

Twelve local maize populations were evaluated at the experimental farm, University of Prishtina, Kosovo. The study was conducted to assess the magnitude of genetic variation in local maize populations for different morphological-physiological and chemical composition under field and laboratory conditions. Randomized complete block design (RCBD) with three replications was used for laying out the experiment. The results showed that there were significant differences for most morphological and physiological traits under study. The mean grain yield of all populations was 102.96 g plant^{-1}. The protein and oil contents ranged between 11.53 to 9.43% and 4.23 to 4.87% respectively. The cellulose content varied from 6.03 to 6.37%. There were also big differences regarding phenotypic correlations. The present study revealed considerable amount of diversity among the local maize populations which could be manipulated for further improvement in maize breeding.

Keywords: diversity, maize, minerals, oil, populations, proteins

Introduction

Plant genetic resources are considered to be priceless and the preservation of biological diversity a matter of the long term sustainability of human life (Everson *et al.,* 1998). The white maize landraces is characterised with a long history and with higher value for different purpose. After its domestication the continuous cultivation accompanied by selection through the environment and humans shaped maize to develop a huge potential for high and stable yield (Aliu *et al.*, 2010). The local maize populations show a great adapting capacity and physiological traits specifics for some areas and productivity capacity and own quality traits too (Hallauer and Miranda, 1981). In the maize breeding the local maize populations could presented a special interest, evenly like useful gene sources for adapting capacity and for physiological and agronomical traits and for valuable quality. (Murariu *et al.,* 2010). Plant adaptation to different biotic and abiotic stresses, as well as to climate changes, is dependent upon existing genetic variability (Micic *et al.,* 2003). Maize growth and productivity depends on many factors such as genetic structure, environmental characteristics and production technology. If environment is not optimal (e.g., in areas with marginal rainfall such as <600 mm per year) the production of maize is considered less reliable (Robertson *et al.*, 2003). Today, a great deal of crop variability is lost, due to massive use of uniform commercial varieties, only about 5% of maize germplasm is in commercial use (Hoisington *et al.*, 1999). For these reason maize germplasm, accumulated through many decades, is stored in gen banks all around the world. Maize (*Zea mays* L.) is an important cereal crop of Kosovo and a major component of animal feeds. Based on area and production it ranks second in cereals next to winter wheat. In 2006 and 2007 maize was grown on a total area of 60.000-70.000 ha^{-1} with a total production of 292.50 thousand tones with average yield 4.5 t ha^{-1} (Aliu *et al.*, 2010). Farmers across different regions in Kosovo have performed their own selection of maize landraces that was based on their practical experience level and knowledge. When maize hybrids were first introduced in Kosovo in the beginning of year 1950, their area was gradually expanded to bigger arable land substituting local maize landraces which are now found only in very narrow rural regions. In Kosova the hybrids genotypes were cultivated on 4% of the maize area during the 1960, while in the beginning of year 2000 they were grown on about 90%. As new hybrids of maize have a high yield potential, their acceptance is rapid. This led, of course, to a dramatic decrease of genetic variability. This genetic erosion of landraces (IEGL) in Kosovo was still low in the period 1955-1965 but it very much intensified during the period 1985-1995 (Fetahu *et al.,* 2005). This phenomenon is not only due to decreased areas cultivated with maize landraces, less than 5% by now, but it also a decreased polymorphism and variability between maize genotypes as the hybrids are closely related. Therefore the risk is real that the existing adapted material will be lost soon, after centuries of selection under the agro ecological conditions of Kosovo. The exploration of these resources can be possible only through complexes studies

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and measures which will determine the biodiversity keeping and the sustainable use of this (Murariu *et al.,* 2010). Genetic diversity plays a key role for future progress in maize breeding. Different breeding methods based on introduction, selection and hybridization have been devised and used successfully for development of improved varieties of maize all over the world. However, the prerequisite for all these breeding procedures is the presence of sufficient amount of genetic variability, wherein desired lines could be selected for further manipulation to achieve the desired objective (Hidayat *et al.,* 2008). The aim of this investigation was to provide the information about the performance of these local maize populations in terms of morphological, physiological and chemical composition traits, which will be helpful to maize breeders for further manipulation in subsequent breeding programs.

Materials and methods

Experimental site

The experiment study area was located at the Prishtina in experimental farm of faculty of Agriculture, Kosovo. It lies between latitude 42°38'97" N and, 21°08'45" E longitude, elevation 571 m.a.s.l. The land has been used continuously for the cultivation of arable crops like winter wheat, maize. This region is with receiving variable rainfall averaging about 613.3 mm per year and has mean annual temperature of about 10.27°C. Summer temperatures in these region sometimes reach more 35°C resulting to high evapotranspiration (HIMK, 2008).

Plant material and experimental design

Twelve (12) local maize populations (LMP's) used in this study were collected in different regions of Kosova (Tab. 1). The twelve LMP,s constituted the treatment which was laid out in a Randomized Complete Block Design with three replicates (RCBD). The land preparation was done by intensive agro technique. Each plot consisted

Tab. 1. Geographical data of investigated Kosovo local maize populations

Number of accession	Locality	Longitude	Latitude	Elevation (m)
'LMP-1'	Gjakovë	20º52´06"	42°52´37"	475
'LMP-2'	Rahovec	20º53´19"	42°38´77"	327
'LMP-3'	Kamenicë	21º48´61"	42°64´38"	668
'LMP-4'	Ferizaj	21º10´23"	42°37´63"	601
'LMP-5'	Hani Elezit	21º27´16"	42°11´48"	736
'LMP-6'	Skenderaj	20º77´69"	42°73´42"	591
'LMP-7'	Podujevë	21º21´07"	42°91´92"	613
'LMP-8'	Obiliq	21º09´12"	42°78´10"	590
'LMP-9'	Mitrovicë	20º91´79"	42°86´46"	578
'LMP-10'	Prishtinë	21º19´64"	42°70´68'	639
'LMP-11'	Istog	20º45´74"	42°76´65"	439
'LMP-12'	Dragash	20º69´35"	42°12´85"	1069

of a row 5 m long with an inter and intra row plant spacing of 0.75 x 0.30 m to give an equivalent plant populations of 47000 plant ha^{-1} . Each plot had $15m^2$ a total of 40 plants which were considered for data collection. Weeding was done manually to the end of plant vegetation.

Measurements

The following data were obtained: Leaf Area (LA), Leaf Area Index (LAI), Leaf Area Ratio (LAR). We measured in field and in laboratory and 5 plants were randomly harvested from one of the middle rows (5 plants x 3 replicates = 15 plant per parameters). Leaf Area (LA) was determined according to the formula: A = L×W×0.75,(Aliu *et al*., 2010), where L is the leaf length, W is the leaf width, 0.75 is the factor of recalculation for maize. Derived physiological parameters of maize were calculated using the following formulas by Radford (1967):

Leaf Area Index (LAI) = Leaf area per Plant x Number of plants m^{-2}.

$$\text{Leaf Area Ratio}(\text{LAR}) = \frac{\text{LAP}}{W_p}(cm^2g^{-1})$$

where Wp-represent weight per plant (biomass), and LAP-is leaf area per plant.

Laboratory studies: At harvest time, five random ears were selected in each plot, giving a total of 10 ears per individual population. Grains were carefully removed by hand. From each population, an equal number of grains was taken from each plot, mixed together in orders to form a balanced sample and then subjected to proximate analyses in the laboratory. The grains obtained were grounded to form a fine powder. The chemical analyses included protein content (PC), cellulose content (CC) and oil content (OC). Analyses were based on standard methods: PC was determined by the Kjeldahl, while OC was determined by extraction using Soxhlet method (using petroleum ether at boiling point 40-60°C). Ash contents of each sample were determined by the dried of sample at 550°C.

Statistical analyses: Data collected from field and laboratory experiments were subjected to ANOVA (descriptive statistics). To determine relationships among traits, the Pearson's correlation was computed. Mean values of the agronomic traits for LMP's populations were standardized and used for computing Euclidean distances between them using MINITAB software. Statistical analysis was performed using the statistical program of MINITAB-14, SPSS.16 (2010) and Excel program.

Results and discussion

The ear plant height (EPH) ranged between 41.33 cm at 'LMP-8' and 86.44 cm in 'LMP-11' (Tab. 2) . The genetic variation for EPH was only 80.42%. Significant amount of variability was revealed among LMP's for plant height (PH). The maximum PH was recorded for 'LMP-11' (129.83 cm) while maize local populations on number

8 attained minimum plant height (79.16 cm). The differences between maize genotypes were 50.67 cm or with genetic variation 52.57%. This variation may be attributed to their genetic background.

The lLeaf area (LA) and its duration are important consideration for photosynthesis a plant especially in maize, these are also the measurements of growth of plants and plant physiological processes (Aliu *et al*., 2010). Effects on LA, LAI and LAR at the different maize local populations are presented in Tab. 2. Differences were found between the LMP's genotypes for LA and LAI trait had highly significant at LSD p= 0.01 level of probability. The maximum LA (5402.35 $cm^2 plant^{-1}$) and LAI (2.53 plant m^2) was noted for 'LMP-11', while on minimum average values (2269.56 $cm^2 plant^{-1}$) respectively (1.06 plant m^2) was characterized 'LMP-8'. It was lower than that reported by Aliu *et al*. (2010). Significant variability was observed among the LMP's for cob diameter, number of seed row, Number of seed, grain depth and 100 seed weights. The final grain yield (g ear^{-1}) in maize crop is the combined effect of various yield components, like number of cob bearing plants, number of cobs per plant, number of grains per cob, weight of grains per cob and 1000 grain weight. Data pertaining to the grain yield per plant are presented in Tab. 2, which reveal that grain yield was significantly for LSD p=0.01. The total average values µ for GY in all investigated LMP's was 102.96 g $plant^{-1}$. The 'LMP-12' produced significantly the maximum average grain yield 120.41 g $plant^{-1}$, while the lowest grain yield (78.33 g $plant^{-1}$) was obtained in 'LMP-5'. The differences between LMp's were 42.08 g $plant^{-1}$ or with genetic variation 40.87%.The variation of oil content (OC) was found to be higher than variation of protein content (PC). The ANOVA indicated that the differences among the LPM's for PC and OC were highly significant at p=0.01 (Tab. 2). The mean value of PC observed in the present study was 10.06%. The LMP's also showed a high genetic variation (20.87%). The variation of the protein content has been well demonstrated by numerous studies. Has *et al*. (2009) at some LMP's reported variation from 11.2 to 15.6%; while Prasanna *et al*. (2001) presented different results which varied from 8.9 to 10.2%. Aliu *et al*.,(2012) reported variation for PC form 11.02 till 13.02%. High oil maize is a special type that has been bred to have higher percent oil content (OC) than regular yellow corn. Typically, oil content of yellow maize varies from 3.5 to 4%. Ideally, high oil maize should contain from 7 to 8% of oil (Heiniger, 1997). The genotype 'LMP-11' exhibited maximum Cellulose Content (CC) on value 6.37, while 'LMP-4' had the lowest value of CC (6.03). Genetic variation was 5.51%. Also, ash content (AC) was with variation which ranged from 1.46 to 1.27%. Increasing the concentrations of Fe and Zn in staple food crops through breeding has been proposed as one strategy to minimize the adverse effects of widespread mineral deficiencies in humans (Menkir, 2008). The differences for chemical composition in our study include; Zn, Fe, Mg, Ca, Na and K among LMP's were highly significant (Tab. 2.; Fig. 1.). Deficiencies in these nutrients can hamper early brain development, suppress the immune system, increase both mortality and morbidity, and reduce the capacity to do physical work (Graham and Welch, 2002).

Tab. 2. Variability of some morpho-physiological and chemical content of LMP's

Trait	Range	Min	Max	Mean	SD*	GV (%)*
Ear Plant Height (EPH)	45.11	41.33	86.44	56.09	13.79	80.42
Plant Height (PH)	50.67	79.16	129.83	96.38	14.77	52.57
Leaf Area (LA)	3132.79	2269.56	5402.35	3905.85	931.56	80.20
Leaf Area Index (LAI)	1.47	1.06	2.53	1.82	0.42	80.76
Leaf Area Ratio (LAR)	6.98	5.98	12.96	10.13	2.02	68.90
Cob Diameter (CD)	0.89	3.74	4.63	4.17	0.24	21.34
Number of Seed Row (NSR)	6.29	7.93	14.22	10.40	1.64	60.48
Number of Seed (NS)	13.23	30.44	43.67	34.99	3.31	37.81
Grain Depth (GD)	0.16	0.80	0.96	0.86	0.04	18.60
100 seed weight	13.66	27.08	40.74	34.88	3.77	39.16
Grain Yield (GY)	42.08	78.33	120.41	102.96	13.82	40.87
Protein Content (PC)	2.10	9.43	11.53	10.06	0.58	20.87
Cellulose Content (CC)	0.34	6.03	6.37	6.17	0.11	5.51
Oil Content (OC)	1.60	3.27	4.87	3.78	0.48	42.32
Ash content (AC)	0.19	1.27	1.46	1.34	0.06	14.17
Zn	17.34	17.33	34.67	27.52	4.32	63.01
Fe	3.00	12.00	15.00	13.33	0.84	22.50
Mg	286.33	658.67	945.00	827.13	85.44	34.61
Ca	24.33	39.00	63.33	48.94	7.30	29.41
Na	105.67	101.00	206.67	126.22	33.23	83.42
K	581.62	1056.83	1638.45	1407.56	191.19	41.32

*SD: standard deviation, *GV: genetic variation

Tab. 3. Pearson correlation coefficients among morpho- physiological and chemical composition

Traits	EPH	PH	LA	LAI	LAR	CD	ERN	EKN	GD	100	GY	PC	CC	OC	Ash	Zn	Fe	Mg	Ca	Na	K
EPH	1	0.951**	.829**	.832**	-.022	-.348	-.207	.203	.256	.198	.117	.509	.701*	.746**	.488	.089	-.627*	.010	.213	.294	-.266
PH	0.951**	1	.812(**	.813**	-.061	-.323	-.142	.260	.283	.086	.136	.471	.643*	.713**	.505	.183	-.681*	.042	-.033	.276	-.239
LA	.829**	.812**	1	.998**	-.163	-.087	.026	.182	.337	.316	.307	.521	.549	.689*	.527	.352	-.310	.171	.366	.571	.023
LAI	.832**	.813**	.998**	1	-.144	-.047	.060	.175	.300	.312	.328	.472	.517	.678*	.494	.375	-.325	.186	.374	.551	.068
LAR	-.022	-.061	-.163	-.144	1	-.364	-.431	.332	-.592*	-.037	-.104	.020	-.176	-.151	-.207	.349	.066	.032	-.122	-.717**	.142
CD	-.348	-.323	-.087	-.047	-.364	1	.779**	-.245	-.036	.121	.468	-.698*	-.630*	-.444	-.545	.243	.086	.346	.159	.162	.581(*)
ERN	-.207	-.142	.026	.060	-.431	.779**	1	-.240	-.037	-.415	.127	-.634*	-.429	-.169	-.319	.337	.257	.390	.237	.305	.594(*)
EKN	.203	.260	.182	.175	.332	-.245	-.240	1	.339	.015	-.050	.193	-.149	-.249	.093	.242	-.047	.013	-.122	-.139	.064
GD	.256	.283	.337	.300	-.592*	-.036	-.037	.339	1	.169	-.013	.275	.209	.078	.146	-.118	-.207	-.002	.095	.509	-.279
100	.198	.086	.316	.312	-.037	.121	-.415	.015	.169	1	.686*	.361	.071	.038	.149	-.232	-.235	-.291	.148	.117	-.147
GY	.117	.136	.307	.328	-.104	.468	.127	-.050	-.013	.686*	1	.077	-.238	.003	.101	-.059	-.150	-.357	-.074	.073	.084
PC	.509	.471	.521	.472	.020	-.698*	-.634*	.193	.275	.361	.077	1	.715**	.547	.802**	-.269	-.049	-.385	-.002	.255	-.619*
CC	.701*	.643*	.549	.517	-.176	-.630*	-.429	-.149	.209	.071	-.238	.715**	1	.860**	.710**	-.183	-.368	-.034	.160	.472	-.646*
OC	.746**	.713**	.689*	.678*	-.151	-.444	-.169	-.249	.078	.038	.003	.547	.860**	1	.701*	.019	-.325	-.078	.251	.520	-.359
ASH	.488	.505	.527	.494	-.207	-.545	-.319	.093	.146	.149	.101	.802**	.710**	.701*	1	-.280	.005	-.424	.024	.510	-.471
Zn	.089	.183	.352	.375	.349	.243	.337	.242	-.118	-.232	-.059	-.269	-.183	.019	-.280	1	.013	.766**	.115	.044	.620*
Fe	-.627*	-.681*	-.310	-.325	.066	.086	.257	-.047	-.207	-.235	-.150	-.049	-.368	-.325	.005	.013	1	-.081	.327	.060	.310
Mg	.010	.042	.171	.186	.032	.346	.390	.013	-.002	-.291	-.357	-.385	-.034	-.078	-.424	.766**	-.081	1	.226	.199	.424
Ca	.213	-.033	.366	.374	-.122	.159	.237	-.122	.095	.148	-.074	-.002	.160	.251	.024	.115	.327	.226	1	.489	.263
Na	.294	.276	.571	.551	-.717**	.162	.305	-.139	.509	.117	.073	.255	.472	.520	.510	.044	.060	.199	.489	1	-.097
K	-.266	-.239	.023	.068	.142	.581*	.594*	.064	-.279	-.147	.084	-.619*	-.646*	-.359	-.471	.620*	.310	.424	.263	-.097	1

EPH-Ear Plant Height ; PH-Plant Height; LA-Leaf Area; LAI-Leaf Area Index; LAR-Lear Area Ratio;CD- Cob Diameter; ERN-Ear Row number; EKN- Ear Kernel Number; GD-Grain Depth; 100 seed weight; GY-Grain Yield; PC-Protein Content; CC-Cellulose Content; OC-Oil Content; AC-Asch Content; Zn-Zinc, Fe-Iron; Mg-Magnesium; Ca-Calcium; Na-Natrium; K-Potassium

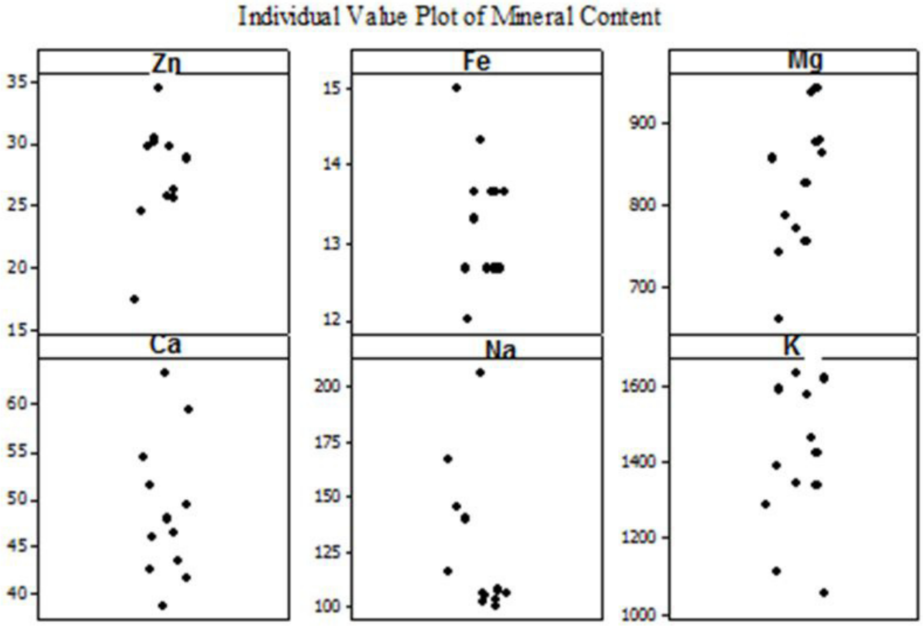

Fig. 1.The individual distribution of mineral content

Pearson correlation among traits shows positive significant correlation between ear plant heights; plant height, leaf area, leaf area index and oil content. Correlation between grain yields, leaf area, leaf area index, protein content and 100 seed weight were also positive (Tab. 3). A high correlation between plant height and ear height has been reported by many authors to range from r=0.78-0.88 (Hallauer and Miranda, 1981; Salami, 2002; Neto *et al.*, 2001). A few studies have reported a negative correlation between grain yield and concentrations of grain minerals in maize (Banziger and Long, 2000).

The cluster analysis reported differentiates between populations on the basis of their similarity. The local maize populations were classified into three main groups. The clustering of local maize populations on the dendrogram in three separate groups resulted from different morphological and qualitative traits. In the dendrogram obtained for 'LMP-11', 'LMP-8' and 'LMP-5' were distinguished, while the 'LMP-1' and 2 had the similarity level with 'LMP-11' only 8.63% (Fig. 2).

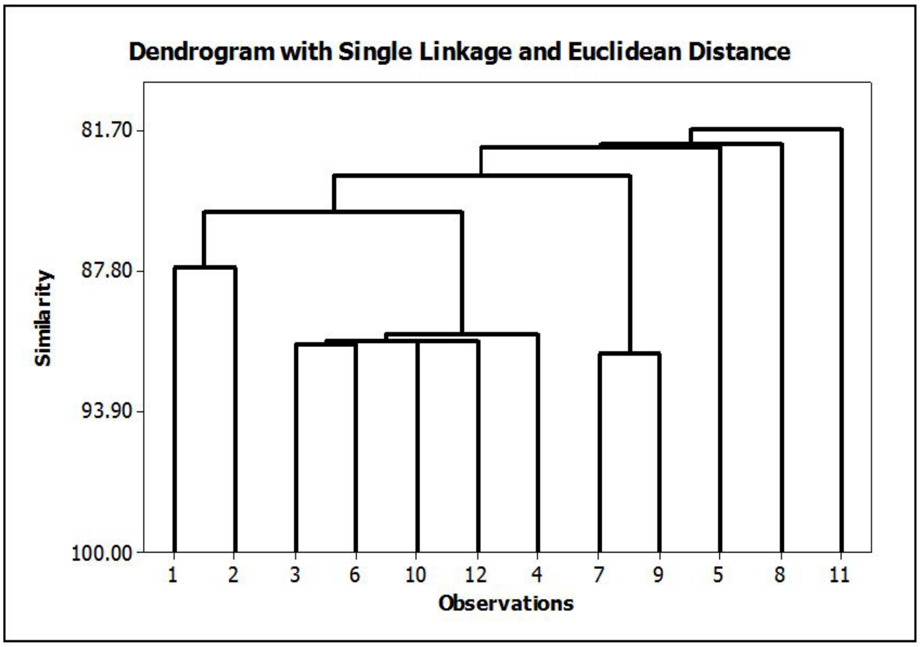

Fig. 2. Genetic grouping of local maize populations by cluster analysis

Conclusions

In the present study, highly significant differences were detected among the local maize populations. It is noted local maize populations of interest as starting material for the improvement of important traits elements of productivity: leaf area, leaf area index, protein, oil and mineral contents. Local populations of maize as a valuable material can be used to launch crossing activities, leading to developing high-yielding maize hybrids.

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