Interrelationships among traits and morphological diversity of wheat (*Triticum aestivum* L.) accessions in base collection of Plant Genetic Resources Institute, Albania

Doriana (Bode) XHULAJ [1*], Fetah ELEZI [1], Valbona HOBDARI [1]

ABSTRACT

The object of the study was the evaluation of the morphological variability of 92 wheat germplasm (*Triticum aestivum* L.) part of *ex situ* collection of Plant Genetic Resources Institute, Agricultural University of Tirana. Principal components and cluster analysis were carried out involving 8 quantitative traits, such as tiller capacity, plant height, spike length, number of spikelet per spike, number of seeds per spikelet, number of seeds per spike, seed size and of seeds per spike. Plant height showed positive significant correlation with yield contributing traits as spike length (r = 0.560) and the number of spikelet's per spike (r = 0.305). The number of grains per spike had a significant positive relationship with the mass of grains per spike. Three principal components exhibited about 66.42 % of variability where two PCs components influenced mostly the variability (PC1 with 28.1 % and PC2 with 24.43 %). Accessions were grouped into three major clusters based on complete linkage, suggesting for a variance at the level of 27.50 % within a class and 72.50 % between classes. The results suggested that plant height, spike length, number of spikelet per spike were the most important characters in differentiating the genotypes.

Key words: bread wheat; cluster; PC; morphology; traits; variability

IZVLEČEK

RAZMERJA MED LASTNOSTMI IN MORFOLOŠKO RAZNOLIKOSTJO AKCESIJ KRUŠNE PŠENICE (*Triticum aestivum* L.) IZ OSNOVNE ZBIRKE Plant Genetic Resources Institute, ALBANIJA

Predmet raziskave je bilo ovrednotenje morfološke variabilnosti 92 genotipov navadne pšenice (*Triticum aestivum* L.) iz *ex situ* zbirke Inštituta za genetske resurse (Plant Genetic Resources Institute), Kmetijske univerze v Tirani (Agricultural University of Tirana). Analiza glavnih komponent in klasterska analiza sta bili izvedeni na 8 količinskih lastnostih kot so sposobnost bilčenja, višina rastlin, dolžina klasa, število klaskov v klasu, število semen v klasku, število semen na klas, velikost semen in masa semen na klas. Višina rastlin je pokazala značilno pozitivno korelacijo z lastnostmi, ki so povezane s pridelkom kot je dolžina klasa (r = 0,560) in število klaskov na klas (r = 0,305). Število zrn na klas je imelo značilno pozitivno povezanost z maso zrn na klas. Tri glavne komponente so pokazale 66,42 % variabilnosti od katerih sta dve prispevali večji del (PC1 28,1 % in PC2 24,43 %). Akcesije so se združevale v tri glavne povezane skupine, kar kaže, da je bila variabilnost znotraj razreda 27,50 % in 72,50 % med razredi. Rezultati kažejo, da so najpomembnejše lastnosti, po katerih se razlikujejo genotipi višina rastlin, dolžina klasa in število klaskov na klas.

Ključne besede: krušna pšenica; grozd; PC, morfologija; lastnosti; variabilnost

1 INTRODUCTION

The Albanian Gene Bank has 3317 accessions of different crops in long-term storage (base collection), where wheat crop place an important role. Among 594 of wheat (*Triticum durum* Desf. and *Triticum aestivum* L.) accessions, approximately 270 accessions belong to bread wheat genotypes. The gene bank has the aim not only to preserve the germplasm but also to make available the plant resources into breeding programs, to improve cultivars or to develop new ones.

The evaluation of genetic variability based on morphological characters especially those of economic interest could also be used to select appropriate materials in breeding programs for crop improvement (Dos Santos et al., 2009). As previously reported (Al Khanjari et al., 2008), quantitative traits are often used to assess and describe the wheat characters due to their role in the estimation of genetic diversity and discrimination of closely related types. They were used to identify duplicates, to establish core collections in gene banks, to investigate relationships between

[1] Institute of Plant Genetic Resources, Agricultural University, Tirana, Albania *Corresponding author: d.xhulaj@yahoo.com

landraces and their wild relatives, and for the most important tool, to prioritize material for use in breeding programs (Ariyo, 1993; Pecetti and Annicciarico, 1992).

Genetic diversity of wheat genotypes can be evaluated using morphological, which contribute toward grain yield as plant height, spike length, number of spikes per spike and grain (Maqbool et al., 2010). The correlation coefficient analysis is useful in the identification of characters that are positively correlated with yield (Maqbool et al., 2010; Bode et al., 2012). The

evaluation of phenotypic variability by multivariate analysis gives the possibility to include a large number of accessions and to identify the most suitable resources for special traits (Goel et al., 2015).

Therefore the object of this study was the characterization of 92 accessions of bread wheat (*Triticum aestivum* L.), part of the base collection of the Albanian Gene Bank (Agricultural University of Tirana), in terms of diversity in morphological traits and association between each pair of these traits.

2 MATERIALS AND METHODS

The study was based on the characterization of the diversity of bread wheat (*Triticum aestivum* L.) germplasm. The plant material was characterized by a survey on land and laboratory, during the year 2016 in the experimental field of the Agricultural University of Tirana. The agronomic characters were measured after harvesting, using 20 plants from each accession.

2.1 Plant materials

In this study, 92 accessions of bread wheat (*Triticum aestivum* L., Table 1.) were used, part of the base collection of PGRI former Albanian Gene Bank (https://eurisco.ipk-gatersleben.de/apex/f?p = 103:25), conserved during 2001-2003.

Table 1: List of the 92 wheat (*Triticum aestivum* L.) accessions object of the study

Code/ AGB	Accession name	Acquire date	Origin	Growth class	Growth habit
0152	BL-76 x MEC 5/1-8 - 4	08.01.03	ALB	winter	upright
0153	LINJA FIKSE VRINE 6/1-1-1-3-4	08.01.03	ALB	winter	upright
0154	YAV x GTA"S"(2)-SO 179 4/3-1-11-1	08.01.03	ALB	winter	upright
0155	LLUCHIANENCO x PAVON 76 3/2-1-2-3	08.01.03	ALB	winter	upright
0156	Ç 2278 x LLUCHIANENCO 11/2-2-1-4-5	08.01.03	ALB	winter	upright
0157	REGINA x L 2076 10/3-3-1-6 258H 1983	08.01.03	ALB	winter	upright
0158	SLLOVENKA x MAJ x L68/3-2 7/6-6-1-1-2	08.01.03	ALB	winter	upright
0159	KAMZA 10 x MEC 7-1-7-1	08.01.03	ALB	winter	upright
0160	MEC x 519 CM 9160 2/1-1-12-3	08.01.03	ALB	winter	upright
0161	KAMZA 10 x MEC 49/1-4	08.01.03	ALB	winter	upright
0221	LP 3-3	26.06.01	ALB	winter	upright
0222	David x Mec	26.06.01	ALB	winter	upright
0223	Dajti	26.06.01	ALB	winter	upright
0224	LVS	26.06.01	ALB	winter	upright
0225	Ni-496	26.06.01	ALB	winter	upright
0226	Ni-594	26.06.01	ALB	winter	upright
0227	Ni-792	26.06.01	ALB	winter	upright
0228	Ni-886	26.06.01	ALB	winter	upright
0229	Ni-896	26.06.01	ALB	winter	upright
0239	-	26.06.01	ALB	winter	upright
0240	-	26.06.01	ALB	winter	prostrate

0241	-	26.06.01	ALB	winter	upright
0242	-	26.06.01	ALB	winter	upright
0243	-	26.06.01	ALB	winter	prostrate
0244	-	26.06.01	ALB	winter	prostrate
0245	-	26.06.01	ALB	winter	prostrate
0246	-	26.06.01	ALB	winter	prostrate
0247	-	26.06.01	ALB	winter	prostrate
0248	-	26.06.01	ALB	winter	prostrate
0249	-	26.06.01	ALB	winter	prostrate
0250	-	26.06.01	ALB	winter	prostrate
0251	-	26.06.01	ALB	winter	upright
0252	-	01.05.02	ALB	winter	upright
0253	-	26.06.01	ALB	winter	upright
0254	-	26.06.01	ALB	winter	upright
0255	-	26.06.01	ALB	winter	upright
0256	-	26.06.01	ALB	winter	upright
0257	-	26.06.01	ALB	winter	upright
0258	-	01.05.02	ALB	winter	upright
0259	-	26.06.01	ALB	winter	upright
0260	-	26.06.01	ALB	winter	upright
0261	-	26.06.01	ALB	winter	upright
0262	-	01.05.02	ALB	winter	upright
0263	-	26.06.01	ALB	winter	upright
0264	-	01.05.02	ALB	winter	upright
0265	-	26.06.01	ALB	winter	upright
0266	-	01.05.02	ALB	winter	upright
0267	-	26.06.01	ALB	winter	upright
0268	-	26.06.01	ALB	winter	upright
0269	-	26.06.01	ALB	winter	prostrate
0270	-	26.06.01	ALB	winter	upright
0271	-	26.06.01	ALB	winter	upright
0272	-	26.06.01	ALB	winter	upright
0273	-	01.05.02	ALB	winter	upright
0274	-	26.06.01	ALB	winter	prostrate
0275	-	26.06.01	ALB	winter	prostrate
0276	-	26.06.01	ALB	winter	prostrate
0277	-	26.06.01	ALB	winter	upright
0278	-	26.06.01	ALB	winter	upright
0279	-	26.06.01	ALB	winter	prostrate
0280	-	26.06.01	ALB	winter	prostrate
0281	-	26.06.01	ALB	winter	upright

0282	-	26.06.01	ALB	winter	prostrate
0283	-	26.06.01	ALB	winter	prostrate
0284	-	26.06.01	ALB	winter	prostrate
0285	-	26.06.01	ALB	winter	prostrate
0286	-	26.06.01	ALB	winter	upright
0287	-	26.06.01	ALB	winter	prostrate
0288	-	26.06.01	ALB	winter	prostrate
0289	-	26.06.01	ALB	winter	upright
0290	-	26.06.01	ALB	winter	prostrate
0291	-	26.06.01	ALB	winter	upright
0292	-	26.06.01	ALB	winter	upright
0293	-	26.06.01	ALB	winter	prostrate
0294	-	01.05.02	ALB	winter	prostrate
0295	-	26.06.01	ALB	winter	upright
0296	-	26.06.01	ALB	winter	upright
0297	-	26.06.01	ALB	winter	upright
0298	-	26.06.01	ALB	winter	upright
0299	-	26.06.01	ALB	winter	upright
0300	-	26.06.01	ALB	winter	upright
0301	-	26.06.01	ALB	winter	upright
0302	-	26.06.01	ALB	winter	upright
0321	-	08.01.03	ALB	winter	upright
0322	-	08.01.03	ALB	winter	upright
0323	-	08.01.03	ALB	winter	upright
0324	-	08.01.03	ALB	winter	upright
0325	-	08.01.03	ALB	winter	upright
0326	-	08.01.03	ALB	winter	upright
0327	-	08.01.03	ALB	winter	upright
0328	-	08.01.03	ALB	winter	upright
0329	-	08.01.03	ALB	winter	upright

2.2 Experimental site

The study was conducted at the Experimental Station of Institute of Plant Genetic Resources Valias, Tiranë. It lies at an altitude of 40 m above sea level and at Latitude 41°24'6.14"N and Longitude 19°44'9.93"E.

2.3 Methods (Experimental Design)

Experiment carried one replication during the autumn season 2016. During the crop year, the accessions were evaluated for different characters of quantitative type as: tiller capacity (TC), plant height/cm (PH), spike length/cm (SL), number of spikelet per spike (SpS), number of seeds per spikelet (GSp), number of seeds per spike (GS), seed size/mm (SeS) and of seeds per spike/g (WGS). Morphological characterization of the accessions was done according to international standards (IPGRI, 1985).

2.4 Statistical analyses

Statistical tests were carried out by the Statistical Package for Social Sciences (version 21) and JPM.

3 RESULTS

To obtain a successful breeding program, it is essential the information that researchers can get on the variability of germplasm within a crop spices. Morphological characterizing of the individual wheat accessions is useful in selection of the adaptable parents in the hybridization process. To assess the genetic diversity among 92 bread wheat germplasm, 8 quantitative traits were used and the estimated variation coefficient was high for agronomic traits as PH, SL, GS and WGS, similar with others authors (Ali et al., 2008; Sabaghina et al., 2014). Regarding PH trait it was observed a variation from 82.9 cm to 180.3 cm, for WGS among 92 accessions the minimum value measured was 0.28 g and the maximum 5.738 g, high variance resulted in GS trait (from ± 12.8 number of seeds per spike to ± 71, Table 2). AGB 0262 recorded the highest value for tiller capacity (± 3.8) whereas the 92 accessions presented an average of 2.56 for the same trait. Sabaghina et al. (2014) reported a higher tiller number (ranging from 1 to 6) measured at 56 bread wheat genotypes. Among the mean value of genotype for plant height trait, accession AGB 0268 recorded the highest mean value (±180.3 cm) and genotype AGB 0258 resulted with the lowest plant height (±82.9 cm). The results are higher from those reported by Sabaghina et al. (2014) plant height variation from 54.9 cm to 109.53 cm, whereas Mahmood et.al. (2006) obtained results ranging from 62 cm to 110 cm, while Aliu et.al. (2010) reported a range from 71 to 79 cm in different bread wheat genotypes.

The variation of plant height trait classified the 92 accessions in different classes (Table 3) where the major number of genotypes resulted from 91-100 cm. Similar results are reported by Peltonen et al. (2007) for the same trait.

Grain yield is influenced by spike properties and the spikelet number plays a very important role in the wheat grain yield (Sabaghina et al., 2014). Spike length in this study varied from 6.40 cm in AGB 0288 to 17.83 cm. Results presented are higher from those reported from other authors (Peltonen et al., 2007; Sabaghina et al., 2014; Xhulaj et al., 2017). Comparing the mean values for SL and number of spikelet's per spike traits, the maximum values were observed in accession AGB 0251 (respectively 17.83 cm and 26.6 cm) followed by AGB 0268. Observations revealed that most of the wheat germplasm (50 accessions) were classified together for spike length trait measured between 9.1 to 11 cm (Table 4).

Table 2: Descriptive statistics of quantitative traits in 92 accessions of bread wheat (*Triticum aestivum* L.)

Statistics	TC	PH	SL	SpS	GSp	GS	SeS	WGS
Observations	92	92	92	92	92	92	92	92
Minimum	2.000	82.900	6.400	10.600	2.100	12.800	3.000	0.280
Maximum	3.800	180.300	17.830	26.600	4.000	71.000	9.000	5.738
Range	1.800	97.400	11.430	16.000	1.900	58.200	6.000	5.458
Mean	2.564	125.280	9.985	19.883	2.994	38.523	6.184	1.788
Variance	0.210	646.808	3.893	10.101	0.119	141.03	0.931	0.578
Standard deviation	0.458	25.432	1.973	3.178	0.345	11.876	0.965	0.760
Variation coefficient %	17.9	20.3	19.8	16.0	11.5	30.8	15.6	42.5
Standard error of ±	0.048	2.666	0.207	0.333	0.036	1.245	0.101	0.080
Mean absolute deviation	0.395	22.330	1.468	2.421	0.223	8.835	0.711	0.543

TC - tiller capacity; PH - plant height/cm; SL - spike length/cm; SpS - number of spikelet per spike; GSp - number of seeds per spikelet; GS - number of seeds per spike; SeS - seed size/mm and WGS - of seeds per spike/g.

In terms of the number of spikelet per spike considerable variance consist between accessions for SpS trait, AGB 0323 recorded the lowest value (10) and AGB 0251 and AGB 0268 the highest value (26.6). Most of the accessions (39) were classified between 19 to 21 numbers of spikelet per spike measured after harvest (Table 6).

Regarding the number of grains per spikelet character, AGB 0322 had the highest mean value (4.0) and AGB 0266 recorded the lowest value (2.1). Among the 92 bread wheat genotypes 23 of the accessions recorded 2.0 to 2.9 number of GSp while 69 of the wheat accessions resulted with 3.0 to 4.0 number of GSp. According to Othmani et al. (2015) this trait is regarded as the main wheat yield component and an increased grain number has been produced by spikes per unit or more grains per spike due to a higher spikelet number.

Data revealed that wheat genotype AGB 0326 presented the highest mean values for two traits, number of seeds per spike (±71) and seed size trait (±9 mm). Regarding GS trait, 92 accessions were grouped in different classes, from 5.43 % presented with 12.0 to 20.0 numbers of grains per spike, till 44.56 % (3.0 to 40.0 GS).

According to Okamoto et al. (2013) the grain number and mass as two main components in wheat grain yield are determined at different times of the growing season. This author suggested that seed mass best-explained genotype by environmental interaction for wheat grain yield. The 92 accessions revealed a high variation regarding this trait, where 26.08 % of them recorded values from 0.2 g to 1.2 g (Table 5), and most of the wheat germplasm (58.69 %) recorded values from 1.3 g to 2.3 g of the same trait. Observation showed that only one accession, AGB 0285 recorded the highest value in mass of seeds per spike (±5.73 g). Seed mass parameter also is important in wheat increasing seed germination percent, seedling emergence, tiller capacity, spike density and yield (Bellatreche et al., 2017).

Seed size trait recorded a high variation from 3.00 mm to 9.00 mm, representing one of the main components of the wheat yield, and increasing grain size continues to be a major breeding target (Sabaghina et al., 2014). Among 92 wheat germplasm in 16.3 % of them seed size varied from 3.0 mm to 5.0 mm, whereas most of the accessions (60.86 %) presented values from 5.0 mm to 7.00 mm for the same trait (Table 5). AGB 0276 had the lowest values for two traits WGS (0.28 g) and seed size (3 mm) followed for this last trait by AGB 0278 and AGB 0221.

Table 3: Classification of 92 wheat (*Triticum aestivum* L.) accessions according to PH trait

Plant height

class/cm	frequency	accession
>80	0	
81-90	5	AGB 0221, AGB 0223, AGB 0226, AGB 0227, AGB 0258
91-100	19	AGB 0152, AGB 0153, AGB 0157, AGB 0158, AGB 0159, AGB 0161, AGB 0224, AGB 0225, AGB 0228, AGB 0229, AGB 0255, AGB 0261, AGB 0302, AGB 0321, AGB 0324, AGB 0325, AGB 0326, AGB 0327, AGB 0328
101-110	10	AGB 0154, AGB 0156, AGB 0160, AGB 0222, AGB 0257, AGB 0272, AGB 0294, AGB 0299, AGB 0300, AGB 0322
111-120	8	AGB 0243, AGB 0254, AGB 0274, AGB 0277, AGB 0278, AGB 0295, AGB 0301, AGB 0329
121-130	8	AGB 0155, AGB 0263, AGB 0271, AGB 0287, AGB 0290, AGB 0296, AGB 0297, AGB 0298
131-140	14	AGB 0241, AGB 0242, AGB 0245, AGB 0252, AGB 0259, AGB0260, AGB 0262, AGB 0264 AGB 0269, AGB 0279, AGB 0280, AGB0282, AGB 0288, AGB 0323
141-150	12	AGB 0240, AGB 0246, AGB 0253, AGB 0256, AGB 0265, AGB 0267, AGB 0270, AGB 0273, AGB 0275, AGB 0276, AGB 0291, AGB 0293
151-160	6	AGB 0239, AGB 0247, AGB 0248, AGB 0249, AGB 0250, AGB0292
161-170	7	AGB 0251, AGB 0266, AGB 0281, AGB 0283, AGB 0285, AGB0286, AGB 0289
171-180	2	AGB 0244, AGB 0284
<181	1	AGB 0268

Table 4: Classification of 92 wheat (*Triticum aestivum* L.) accessions according to SL trait

Spike length

class/cm	frequencyy	accession
> 6	0	
6.1-8	29	AGB 0255, AGB 0258, AGB 0271, AGB 0273, AGB 0275, AGB 0276, AGB 0278, AGB 0279, AGB 0280, AGB 0287, AGB 0288, AGB 0290, AGB 0294, AGB 0321, AGB 0322, AGB 0325, AGB 0327, AGB 0328, AGB 0329
9.1-11	50	AGB 0152, AGB 0156, AGB 0157, AGB 0158, AGB 0159AGB 0160, AGB 0161 AGB 0222, AGB 0223, AGB 0224, AGB 0227, AGB 0241, AGB 0245, AGB 0246, AGB 0247, AGB 0249, AGB 0250, AGB 0252, AGB 0253, AGB 0257, AGB 0259, AGB 0260, AGB 0261, AGB 0262, AGB 0263, AGB 0264, AGB 0267, AGB 0270, AGB 0272, AGB 0274, AGB 0277, AGB 0281, AGB 0282, AGB 0283, AGB 0284, AGB 0285, AGB 0286, AGB 0291, AGB 0293, AGB 0295, AGB 0296, AGB 0297, AGB 0298, AGB 0299, AGB 0300, AGB 0301, AGB 0302, AGB 0323, AGB 0324, AGB 0326
12.1-13	8	AGB 0240, AGB 0242, AGB 0244, AGB 0256, AGB 0265, AGB 0269, AGB 0289, AGB 0292
14.1-16	4	AGB 0239, AGB 0248, AGB 0266, AGB 0268
<17.1	1	AGB 0251

Table 5: Accessions of bread wheat (*Triticum aestivum* L.) frequency (%) distribution

Trait

Number of seeds per spike		Seed size		Mass of seeds/spike	
Class/nr.	Frequency %	Class/mm	Frequency %	Class/g	Frequency %
12-20	5.43	3.0-5.0	16.30	0.2-1.2	26.08
21-30	14.13	5.0-7.0	60.86	1.3-2.3	58.69
31-40	44.56	7.0-9.0	22.82	2.4-3.4	14.13
41-50	20.65	>9.0	0.00	4.6-5.6	1.08
51-60	10.86				
61-70	3.26				
>70	1.08				

Table 6: Classification of 92 wheat (*Triticum aestivum* L.) accessions according to SpS trait

Number of spikelets per spike

class/nr.	frequency	accession
10-12	2	AGB 0153, AGB 0323
13-15	3	AGB 0242, AGB 0243, AGB 0288
16-18	28	AGB 0152, AGB 0154, AGB 0155, AGB 0156, AGB 0221, AGB 0226, AGB 0228, AGB 0252, AGB 0253, AGB 0255, AGB 0257, AGB 0258, AGB 0261, AGB 0262, AGB 0272, AGB 0273, AGB 0274, AGB 0278, AGB 0279, AGB 0281, AGB 0282, AGB 0289, AGB 0290, AGB 0294, AGB 0302, AGB 0328, AGB 0329, AGB 0271
19-21	39	AGB 0158, AGB 0249, AGB 0224, AGB 0227, AGB 0240, AGB 0246, AGB 0247, AGB 0159, AGB 0250, AGB 0225, AGB 0227, AGB 0254, AGB 0241, AGB 0286, AGB 0160, AGB 0259, AGB 0263, AGB 0275, AGB 0280, AGB 0283, AGB 0287, AGB 0161, AGB 0260, AGB 0264, AGB 0276, AGB 0293, AGB 0284, AGB 0300, AGB 0295, AGB 0296, AGB 0265, AGB 0297, AGB0298, AGB 0299, AGB 0301, AGB 0324, AGB 0325, AGB 0326, AGB 0327
22-24	9	AGB 0157, AGB 0223, AGB 0245, AGB 0256, AGB 0269, AGB 0270, AGB0291, AGB 0321, AGB 0322
25-27	11	AGB 0222, AGB 0244, AGB 0248, AGB 0251, AGB 0266, AGB 0267, AGB 0268, AGB 0292, AGB 0239, AGB 0277, AGB 0285

3.1 Correlation Coefficient Analysis

Correlation of morphological traits was calculated by studying the data of bread wheat germplasm (Table 7). Correlations measure the interdependence between a pair of characters. Knowledge of correlation is required to obtain the expected response of other traits when selection is applied to the trait of interest in a breeding program (Maqbool et al., 2010). Plant height showed positive significant correlation with yield contributing traits as spike length (r = 0.560) and the number of spikelet's per spike (r = 0.305).

Same results are reported from previous studies (Maqbool et al., 2010; Xhulaj et al., 2017). While significant negative correlation is observed among TC and SpS (r = -0.358). The number of spikelet per spike had a positive correlation with spike length trait (r = 0.589). Whereas number of grains per spike had a significant positive relation with if grains per spike trait (r = 0.719), supported by other works (Khaliq et al., 2004; Xhulaj et al., 2017).

3.2 Principal component analysis

The average data was analyzed using principal component analysis. According to the data (Table 8), three principal components exhibited about 66.42 % of variability where two PC components influenced mostly the variability (PC1 with 28.1 % and PC2 with 24.43 %; Figure 1).

Table 7: Correlation matrix among the morphological traits (Pearson (n))

Variables	TC	PH	SL	SpS	GSp	GS	SeS	WGS
TC	**1**	-0.126	-0.282	-0.358	-0.013	0.241	-0.102	-0.015
PH	-0.126	**1**	0.560	0.305	-0.012	-0.053	-0.104	0.029
SL	-0.282	**0.560**	**1**	0.589	0.095	0.102	0.046	0.196
SpS	-0.358	**0.305**	**0.589**	**1**	0.064	-0.018	-0.024	0.168
GSp	-0.013	-0.012	0.095	0.064	**1**	0.177	0.231	0.136
GS	0.241	-0.053	0.102	-0.018	0.177	**1**	0.275	**0.719**
SeS	-0.102	-0.104	0.046	-0.024	0.231	0.275	**1**	0.283
WGS	-0.015	0.029	0.196	0.168	0.136	0.719	0.283	**1**

Table 8: Eigen values and percentage of total variance for PCA in 92 accessions of wheat

	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8
Eigen value	2.248	1.955	1.111	0.898	0.712	0.534	0.320	0.221
Variability (%)	28.101	24.435	13.887	11.220	8.904	6.678	4.006	2.768
Cumulative %	28.101	52.537	66.424	77.644	86.548	93.226	97.232	100.000

Table 9: Eigenvectors contribution in 92 accessions of wheat

	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8
TC	-0.277	0.279	-0.544	**0.426**	0.097	0.555	-0.097	-0.202
PH	**0.378**	-0.284	-0.349	0.309	0.493	-0.353	-0.412	0.145
SL	**0.555**	-0.193	-0.127	0.112	0.106	0.178	0.720	-0.255
SpS	**0.484**	-0.234	0.044	-0.119	-0.407	0.562	-0.420	0.194
GSp	0.169	0.228	**0.431**	0.775	-0.320	-0.167	-0.038	-0.036
GS	0.234	**0.578**	-0.285	-0.078	-0.087	-0.094	0.213	0.679
SeS	0.166	**0.362**	**0.518**	-0.089	0.660	0.345	-0.105	0.007
WGS	**0.356**	**0.481**	-0.172	-0.285	-0.159	-0.254	-0.262	-0.610
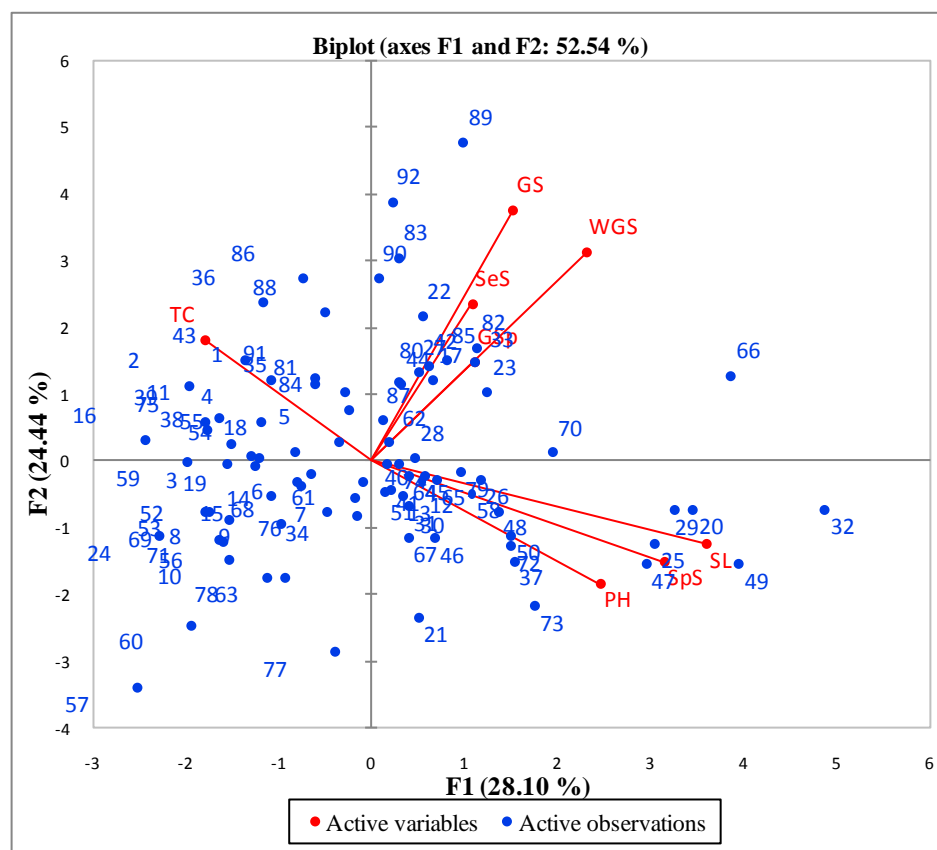
Figure 1: Principal component biplot of 92 wheat (*Triticum aestivum* L.) accessions

The first PC was related with plant height, spike length, number of spikelets per spike and of seeds per spike traits (Table 9) giving about 28.1 % of the variability but poor in tiller capacity. In the second PC traits as number of seeds per spike, seed size and WGS contribute at the level of 24.43 % of variability. The third principal component exhibited positive effects for seed size and number of seeds per spikelet (13.88 %), and maximum variation was observed for tiller capacity, plant height and number of seeds per spikelet at fourth, PC but poor in SL, SpS, GS and WGS. Different authors (Escobar-Hernandez et al., 2005; Othmani et al., 2015) used principal component method for grouping of germplasm. In addition to cluster analysis, biplot has been applied to study relation among studied traits in a set of genotypes (Aghaee et al., 2010; Peterson et al., 2005; Yan and Fregeau – Reid, 2008). Biplot (genotype by trait) explained the percentage variance associated with each principal component obtained by drawing a graph between Eigen values and principal components number.

The biplot (Figure 1) suggest that the best or the incompatible wheat genotypes in most of the traits, since they had the longest distance from the origin for the two principal components were AGB 0251 (32),

AGB 0326 (89), AGB 0268 (49), AGB 0239 (20), AGB 0261 (42), AGB 0261 (29), AGB 0244 (25) , AGB 0227 (17), AGB 0266 (47), and AGB 0329 (92). This group is followed by others genotypes with similar high results in different traits as AGB 0302 (83), AGB 0327 (90), AGB 0241 (22), AGB 0255 (36), AGB 0323 (86), AGB 0285 (66) and AGB 0292 (73).

Therefore it seems that for the first PC genotypes (numbered at Figure 1) 32, 29, and 20 have the highest values mostly for spike length and number of spikelets per spike traits, while genotypes as 49, 47, 25, 73, resulted with the highest values basically for plant height trait, and the other related cultivars as 37, 72, 50 which fall in its sector were suitable for PH too. The genotype 66 is different from the other genotypes in its sector in relation for of seeds per spike trait. The genotypes that presented not suitable performance for the measured traits within the first component, with lower distance from the origin of the biplot were AGB 0276 (57), AGB 0226 (16), AGB 0153 (2), AGB 0278 (59) and AGB 0243 (24).

According to the PC analyze the wheat genotypes that presented the highest variability for the traits in the second component especially for number of seeds per

spike, seed size and of seeds per spike were 36, 89, 86, 88, 90, 83 and 92. Within this component the group of genotypes AGB 0240 (21), AGB 0279 (60), AGB 0282 (63), AGB 0296 (77), AGB 0275 (56) and AGB 0297 (78) resulted with the lowest performance for the measured traits (Figure 1).

The vector view of the biplot suggest a strong positive correlation among traits as WGS and GS, GSp, SeS; between SpS and SL, PH; also among SeS and GSp, GS as indicated by the small obtuse angles between their vectors. The correlation between WGS and PH, SpS, SL; among SeS and SL; between GSp and SL, SpS; and finally GS and SL was near zero as indicated by the near perpendicular vectors. The vectors indicated by the near angle of approximately 180 degrees, suggest for the existence of a strong negative correlation between TC and SpS, SL and PH; also between SeS and PH.

Comparing the Eigen values for each factor using the minimum Eigen value criterion, there are 3 main PC with Eigen values > 1.00 (Table 9 and Figure 1) that influence the genetic variability among 92 wheat genotypes. PC1 showed 28.1 % of variability with Eigen value 2.24 in germplasm which then reduced gradually. After the fourth PC little variance was observed and it ended at 2.76 % with Eigen value 0.22.

From the graph (Figure 1) the maximum variation was present in the first PC. So the selection of genotypes with desirable characters from this PC will be useful for further breeding programs.

3.3 Cluster analysis

The 92 wheat accessions were grouped according to quantitative traits into three major clusters based on complete linkage, whereas each cluster was statically different from each other (Figure 2). Cluster 1 consisted of 41 accessions, cluster 2 of 32 wheat accessions and the third cluster with 19 accessions (Table 10).

The variance calculated within the classes ranged from the maximum variance within class 249.63 at the second

class to the minimum variance value 129.31 at third class.

The maximum distance to centroid at first class is 32.10, at second class 29.54 and for the third class 19.76. The results suggest for variance decomposition for the optimal classification at the level of 27.50 % within the class and 72.50 % between classes. The two clusters with most similarity observed are cluster two and three (27.06 D2 Euclidean distance among them), and with the highest cluster distance value (60.87 units) of dissimilarity were cluster one and three. This dissimilarity was basically due to traits as plant height, spike length, number of grains per spike and seeds . Similar results related to wheat germplasm grouping were reported before (Maqbool et al., 2010; Xhulaj et al., 2017). Two most closely wheat genotypes within the first cluster are AGB 0296 and AGB 0297 (2.19 Euclidean distance), similar for traits as plant height and number of seeds per spikelet. These two accessions were joined from another sub-cluster formed by AGB 0225 and AGB 0159 (2.395 Euclidean distance) similar for plant height and of seeds per spike. Similarity is observed among AGB 0261 and AGB 0228 basically for number of spikelets per spike, also sub-clustered together for high level of similarity especially for spike length trait and plant height are AGB 0265 and AGB0240. Wheat genotypes with the lowest level of similarity at the second cluster are AGB 0296 and AGB 0297 (4.413 distance) and AGB 0287 with AGB 0155 (4.461 Euclidean distance) fully similar for number of seeds per spike trait. Similarity for tiller capacity sub-cluster genotypes AGB 0271 and AGB 0155. Within the third cluster major similarity is observed among AGB 0281 and AGB 0283 especially for tiller capacity, plant height and number of seeds per spike, joined to this pair AGB 0284 for traits as spike length, number of spikelets per spike and seed size.

Observing the clusters, accessions grouped in cluster three, resulted with the highest mean values in traits (PH, SL, SpS) that can contribute positively in the wheat yield and breeding programs.

Table 10: Clusters composition with 92 accessions (Code AGB) of bread wheat

Cluster I	0153	0154	0156	0157	0158	0159	0160	0161	0221
	0222	0223	0224	0225	0226	0227	0228	0254	0255	0257
	0258	0261	0272	0274	0277	0278	0294	0295	0299	0300
	0301	0302	0321	0322	0324	0325	0326	0327	0328	0229
	0329									
Cluster II	0155	0240	0241	0242	0243	0245	0246	0252	0253
	0259	0260	0262	0263	0264	0265	0269	0270	0271	0256
	0273	0323	0275	0276	0279	0280	0282	0287	0288	0298
	0296	0297	0290							
Cluster III	0239	0244	0247	0248	0249	0250	0251	0266	0281
	0283	0284	0285	0286	0289	0291	0292	0293		
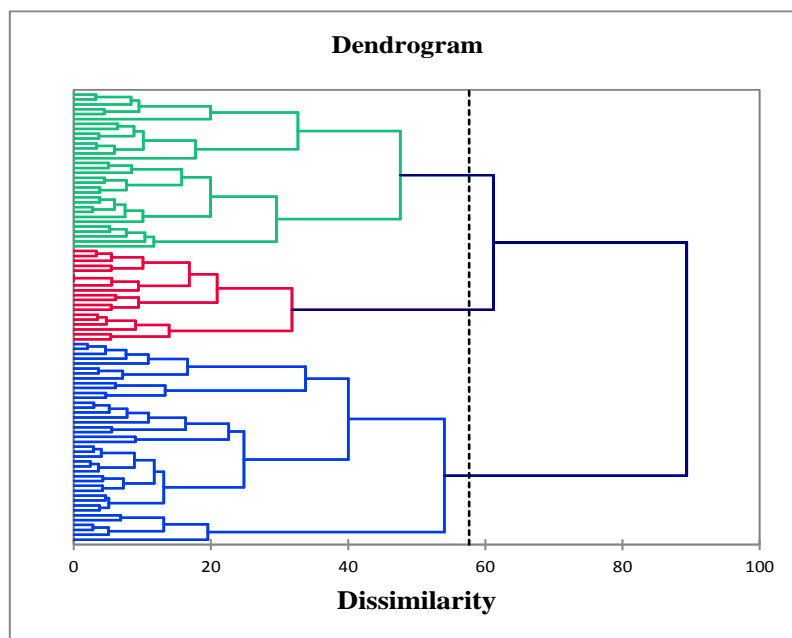
Figure 2: Dendrogram from cluster analysis of 92 bread wheat accessions based on quantitative traits

4 CONCLUSION

Results of this study succeed in obtaining important scientific information on wheat germplasm database stored in the Albanian Gene Bank, and for further wheat breeding programs. The significant differences found in the present study show the existence of a high genetic variability among the 92 bread wheat genotypes and quantitative traits analysed, adequate for selection of desirable traits, and creation of new favourable gene combinations. Among the mean value of genotype for plant height trait, accession AGB 0268 had the highest mean value for SL and the number of spikelets per spike traits, the maximum values were observed in accession AGB 0251 followed by AGB 0268. Regarding number of grains per spikelet character, AGB 0322 had the highest mean value. Data revealed that wheat genotype AGB 0326 presented the highest mean values for GS and seed size trait. AGB 0276 had the lowest values for two traits WGS and seed size followed for this last trait by AGB 0278 and AGB 0221. Three principal components exhibited about 66.42 % of variability where two PCs components influenced mostly the variability (PC1 with 28.1 % and PC2 with 24.43 %). The results suggested that plant height, spike length,

number of spikelet per spike were the most important characters in differentiating the genotypes. The use of principal component analysis (showing the largest contributor to the total variance) and correlation coefficient analysis in the wheat germplasm, simplify dependable classification of genotypes, the identification of the superior genotypes (considering the evaluation of mean values) and their relation with morphological traits with possibility expenditure in breeding programs. Identification of the most important quantitative agronomical traits in wheat can facilitate selection of any individual accession and of desirable traits (genes), increasing the information of the wheat germplasm in gene bank.

The traits with more significant weighting on respective PC variance can be utilised successfully as quantitative markers for evaluation, characterization of the wheat germplasm stored in gene bank. Possible parental lines among these bread wheat genotypes that are in conservation in Albanian Gene Bank could be selected and utilised for sustainable field wheat breeding programs.

5 REFERENCES

Ali, Y., Atta, B. M., Akhter, J., Monneveux, P., Lateef, Z. (2008). Genetic variability association and diversity studies in wheat (*Triticum aestivum* L.) germplasm. *Pakistan Journal of Botany*, *40*, 2087-2097.

Aliu, S., & Fetahu, S. (2010). Determination on genetic variation for morphological traits and yield components of new winter wheat (*Triticum aestivum* L.) lines. *Notulae Scientia Biologicae*, *2*, 121-124. https://doi.org/10.15835/nsb213594

Al Khanjari, S., Fialatenko, A. A., Hammer, K., Buerkert, A. (2008). Morphological spike density of Omani wheat. *Genetic Resources Crop Evolution*, *55*, 1185-1195. https://doi.org/10.1007/s10722-008-9319-9

Aghaee, M., Mohammadi, R., Nabovati, S. (2010). Agro-morphological characterization of durum wheat accessions using pattern analysis. *Australian Journal of Crop Sciences*, *4* (7), 505-514.

Ariyo, O.J. (1993). Genetic diversity in West African okra (*Abelmoschus caillei*) multivariate analysis of morphological and agronomic characteristics. *Genetic Resources and Crop Evolution*, *40*, 25-32. https://doi.org/10.1007/BF00053461

Bellatreche, A., Mahdad, M., Kaouadji, Z., - Gaouar, S. (2017). Agro-morphological diversity of some accessions of bread wheat (*Triticum aestivum*) in western Algeria. *Biodiversitas Journal*, *18* (1), 409-415. https://doi.org/10.13057/biodiv/d180153

BODE, D., Elezi, F., Gixhari, B. (2013). Morphological characterization and interrelationships among descriptors in *Phaseolus vulgaris* accessions. *Agriculture and Forestrey*, *59*(2), 175-185.

Dos Santos, T. M., Gananança, F., Slaski, J. J., Pinheiro de Carvalho Miguel, A. A. (2009). Morphological characterization of wheat genetic resources from the Island of Madeira, Portugal. *Genetic Resources Crop Evolution*, *56*, 363-375. https://doi.org/10.1007/s10722-008-9371-5

Escobar-Hernandez, A., Troyo-Dieguez, T., Garcia, J.L., Murillo-Amador, B., Lopez-Agilar, R. (2005). Principal component analysis to determine forage potential of salt grass *Distichlis spicata* L. in coastal ecosystems of Baja California, Mexico, *Tec. Pecu. Mexu.*, *43*, 13-25.

Goel, S., Humaraswamy, H.H., Grewal, S., - Singh, K., Jaat, S.R., Singh, K.N. (2015). Morphological and agronomical characterization of common wheat landraces (*Triticum aestivum* L) collected from

different regions of India. *International Journal of Current Research and Academic Review*, *11* (3)*,* 14 - 23.

IPGRI. (1985). *Descriptors for Wheat (Revised)*. Institute of Plant Genetic Resources, Rome, Italy.

Khaliq, I., Parveen, N., – Chwodhry, M. A. (2004). Correlation path coefficient analysis in bread wheat. *International Journal of Agriculture and Biology*, *6,* 633-635.

Mahmood, Q., Lei, W. D., Qureshi, S., - Khan, M. D. (2006). Heterosis, correlation and path analysis of morphological and biochemical characters in wheat (*Triticum aestivum* L.). *Agricultural Journal*, *1,* 180-185.

Maqbool, R., Sajjad, M., Khaliq, I., - Rehman, A., Khan, S. A., Khan, H. S. (2010). Morphological diversity and trait association in bread wheat (*Triticum aestivum* L.). *American-Eurasian Journal of Agriculture and Environment Sciences*, *8*(2)*,* 216-224.

Othmani, A., Mosbahi, M., Ayed, S., Slim Amar, H., Boukaber, M. (2015). Morphological characterization of some Tunisian bread wheat accessions. *Journal of New Sciences*, *15*(3)*,* 503-510.

Okamoto, Y., Nguyen, A.T., Yoshioka, M., Iehisa, J. C. M Takumi, S. (2013). Identification of quantitative trait loci controlling grain size and shape in the D genome of synthetic hexaploid wheat lines. *Breeding Science*, *63,* 423-429. https://doi.org/10.1270/jsbbs.63.423

Pecetti, L., Annicchiarico, P., Damania, A. B. (1992). Biodiversity in a germplasm collection of durum wheat. *Euphytica*, *60*,229-238.

Peltonen-Sainio, P., Kangas, A., Salo, Y. (2007). Grain number dominates grain weight in temperate cereal yield determination: Evidence based on 30 years of multi-location trials. *Field Crop Research*, *100,* 179-188. https://doi.org/10.1016/j.fcr.2006.07.002

Peterson, D. M., Wesenberg, D. M., Burrup, D. E., - Erickson, C. A. (2005). Relationships among agronomic traits and grain composition in oat genotypes grown in different environments. *Crop Sciences*, *45,* 1249-1255. https://doi.org/10.2135/cropsci2004.0063

Sabaghina, N., Janmohammadi, M., Segherloo, A. (2014). Evaluation of some agro-morphological traits diversity in Iranian bread wheat genotypes. *UMCSBIO*, *19,* 79-90. https://doi.org/10.2478/umcsbio-2013-0006

SPSS, Statistics. (2016). www.ibm.com/products/spss-statistics

Yan, W., & Freageau-Reid, J. (2008). Breeding line election based on multiple traits. *Crop Sciences*, *48,* 417-423. https://doi.org/10.2135/cropsci2007.05.0254

Xhulaj, B. D., Hobdari, V., Shehu, D., Gixhari, B., Elezi, F. (2017). Agro morphological characterization performance of 100 common wheat (*Triticum aestivum* L.) accessions. *Albanian Journal of Agricultural Science*, *16*(2)*,* 219-227.