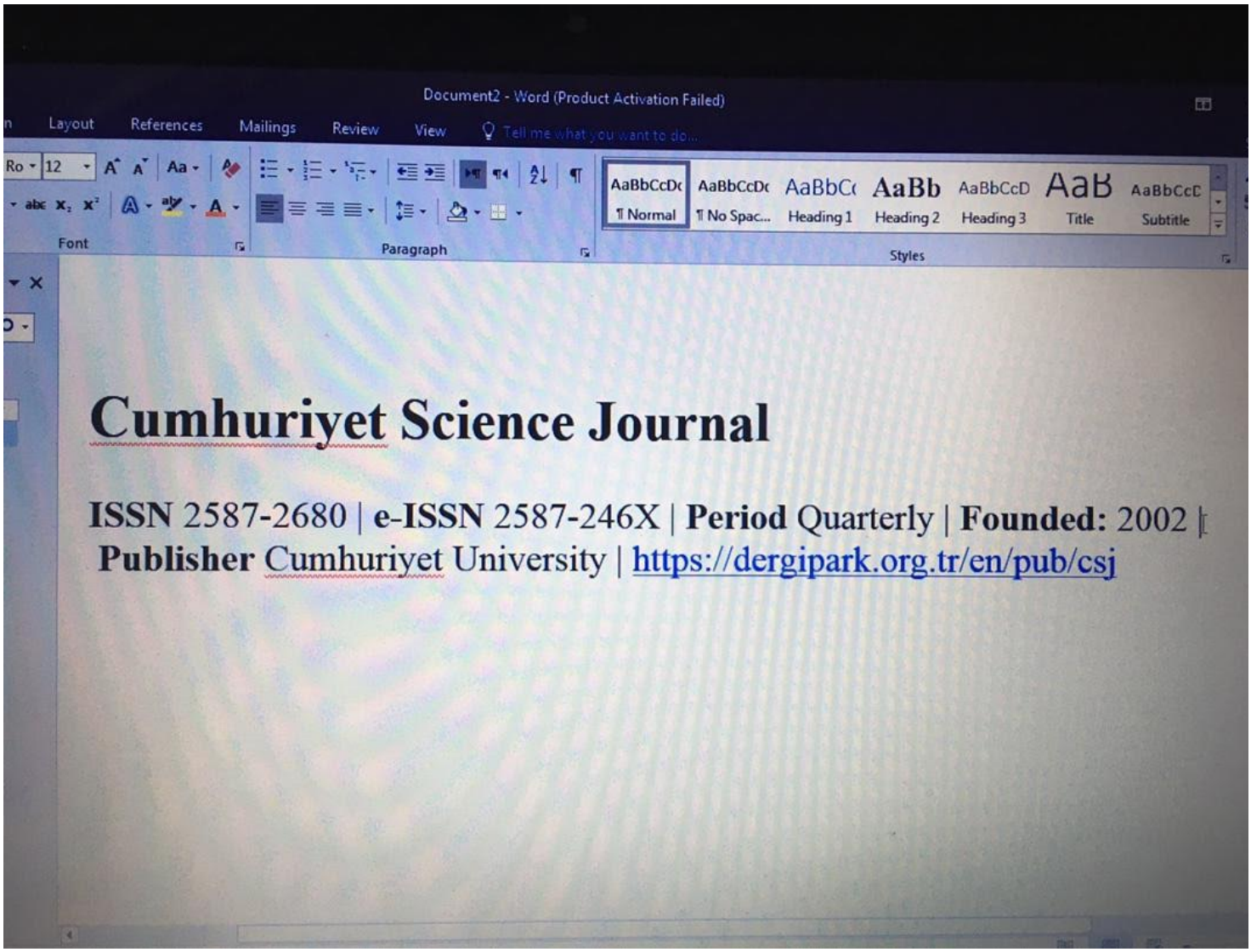
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Evaluation of Genetic Diversity of Morphological Traits in *Elymus tauri* Populations

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Abstract. In this study the genetic diversity of morphological traits in *Elymus tauri*, seeds of 12 populations from East Azabaijan, Ardabil, Kordestan and Alborz provinces were collected. The seeds were planted in Randomized Complete Block Design (RCBD), with four replication, in Tabriz Botanical Garden.Analysis of Variance showed that there was a significant difference among populations at %1 probability level in all traits under study. Cluster Analysis of data based on Ward method, differentiated 12 populations in 2 groups.In Principal Component Analysis, the contribution of the first and second components was higher than %73.In the explanation of the first component, the traits of total number of tillers, spike length and fertile tiller numbe had high positive and significant rates.Grouping obtained from Cluster Analysis was confirmed with the results of Principal Component Analysis.

Keywords: Cluster Analysis,*Elymus tauri*,Genetic Diversity,Principal Component Analysis

1. INTRODUCTION

Grasses are prevailing vegetation of rangelands.In dry and semi-dry areas and irrigated conditions,forage grasses yield higher than forage legumes,and have higher water use efficiency.[16,18].The plant roots develop up to 2 meters, so it is appropriate for soil stabilization and erosion prevention.[3].Grasses play an important role in environmental protection of arid lands,revitalization,and creation of natural landscapes.[9].Form the sustainable agriculture perspective, cultivation of forage grasses not only prevents degradation of soil fertility due to erosion,but it also plays important part in protein food production for man.[10].Prior to flowering stage in grasses,leaf formation continues during or after every harvest; thus, grasses have a good compatibility with grazing and harvest.In addition,many wheat grasses are adapted to steppe zones or desert regions with semi-humid to dry climates.[12].The *Elymus* genus is one of the most important genera of Gramineae family,and one of the most important grasses of semi-dry and temperate areas,as well.This genus grows in cold and temperate steppe regions,and has a considerable rangeland value.[4,17].Perennial species of this genus are drought resistant,and have a very high tolerance rate of ecological

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changes.[2].They are valuable for supplying rangeland forage,improving rangelands,and managing water resources.[5].In regard with yield and fodder quality,they are placed in the category of desirable rangelands plants.[23].*Elymus tauri* Boiss.& Balansa.,is a perennial grass, with strong roots resistant to overgrazing,up-right long stems with thin evergreen leaves. From palatability point of view,it is classified in class one.It is also a species resistant to cold and drought,which grows on rocky slopes of Azarbaijan,Alborz,parts of Zagros and it has formed communities in some steeps such as north of Alborz,East of Sanandaj,Qazvin plain, Karaj valley,and west of Shahr kord.Its seed is included in rangeland species which survives 2-3 years in the ground and maintains its viability.In Iran,there are three varieties of this species with similar ecological characteristics.[13,18].It can be used for seeding in rocky mountainous regions and eroded soils. This plant tolerates a range of temperatures from -20°C to +38°C.Generally,planting of these species is possible from early autumn to late spring,depending on different areas.In case of spring planting,in the first year it will have only vegetative growth without seed production.[23].Because of its palatability and specific features,this species is considered as a plant with rangeland value,and can be effectively used in line with the improvement and revival of the country's rangelands.[1].Existence of diversity for morphological traits in forage grasses has been reported by many researchers like Deway (1976),Nguyen and Sleper (1983,Abdi (2003)[6,21,1] reported the genetic diversity of 8 populations from *Elymus tauri* for fertile tiller number,total tiller number,spike length,flag leaf length,plant dry weight traits.Cluster analysis using Ward method placed 8 Iran's populations in two different groups,which matched the primary habitat origins.Karimzadeh et al (2012)[13]reported genetic diversity for flag leaf length,second leaf length,tiller number,leaf number, plant height, plant dry weight, plant wet weight,canopy,first inter node length,second inter node length,wet forage yield,and dry forage yield traits, in 13 populations of *Agropyron tauri*.Cluster analysis of the standardized data based on Ward method and squared Euclidean distance,clustered 13 populations in three groups,which followed the altitude of geographical regions of the populations.[13].In Principal Component Analysis,four components were introduced.In the first component which justified %61.44 of variance,tiller number,leaf number,plant height,plant dry weight, canopy cover,first inter node length,second inter node length,wet forage yield, and dry forage yield traits had high positive rates.Grouping resulted from Cluster Analysis matched the results of Principal Component Analysis.Kazemi et al.(2013)[15]concluded that drought resistance in 12 populations from *Agropyron cristatum* species, had no effect on survival,flag leaf length, spike length,and spikelet number of

accessions, whereas it had significant effect on fertile tiller percentage,peduncle length,plant height, and straw yield.Rafezi et al.(2008),Farshadfar et al.(2011)[22,7]reported that,there is genetic diversity among *Agropyron elongatum* genotypes.Rahmani et al.(2006)[24]reported a significant difference among 18 ecotypes of *Agropyron cristatum* in forage quality and yield.In order to evaluate the genetic diversity and grouping of *A.elongatum genotypes*,using Cluster Analysis and Principal Component Analysis.Jafari et al.(2010)[11]classified the genotypes in three groups.Grouping from Cluster Analysis matched the grouping from Principal Component Analysis.This research aimed at studying the genetic diversity of the different populations of *Elymus tauri*,and introducing more supreme populations in terms of forage yield and other estimated traits.

2. MATERIAL AND METHODS

The experiment materials included 12 populations from *Elymus tauri* species (Table 1).The experiment was performed in Tabriz Botanical Garden which is located at 38° 8' north and 46° 17' west on the northwest of Tabriz,Iran at the margin of Talkherood river. The place has an altitude of 1350 meter and precipitation of 250 – 280 mmr.The region has semi-dry climate,heavy clay top-soil and light sandy sub-soil.The groundwater of the region is partially saline and alkaline.Soil texture is of the light loam-sandy type.Organic matters and fertile elements are weak to moderate.Average Electrical Conductivity was measured 2.6 ms/cm.Since cations and anions in the matter accumulation layer are often more than other soil horizons,soil pH is alkaline (pH = 7.55) around the region.[15].The experiment was conducted in Randomized Complete Blocks Design,with 4 replication,in Tabriz Botanical Garden.First,in early August,3 to 5 seeds were planted in plastic pots.After germination,the plantlets were transplanted in the field.To prevent competing adverse effect among the plants,4 lines out of each plot were planted.The distance between planting lines was determined 40 cm.Irrigation and weeding were done during growth period.The 10 plants from two middle rows of each plot were selected randomly for measuring.The morphological traits of total tiller number,fertile tiller number,non-fertile tiller number,flag leaf length,second leaf length,peduncle length,canopy, leaf number in tiller,plant height,spikelet number,flag leaf width,spike length,plant wet weight,plant dry weight,wet yield,and dry yield were measured and recorded.Least Significant Difference (L.S.D) method at %5 probability level was used for mean comparison.Cluster Analysis of 12 populations in *Elymus tauri* species was done based on the mean of morphological traits using

Ward method.In order to determine important traits of genetic diversity,Principal Component Analysis were done.For data analysis,SAS 9.2,STATISTICA 6 and XLSTAT 2010 softwares were used.

Table 1. Informations of of *Elymus tauri* populations used in Genetic Diversity of Morphological Traits study

Code	Location	Altitude(m)	Code	Location	Altitude(m)
1	Goljar/Marand/East Azarbaijan	1600	7	Payam/Marand/East Azarbaijan	1900
2	Goychokhour/MeshkinshahrArdabil	2000	8	Zonouz/East Azarbaijan	1400
3	Seyvan /Marand/East Azarbaijan	1600	9	Jolfa/ East Azarbaijan	1200
4	Sofian/East Azarbaijan	1700	10	Horand/ East Azarbaijan	950
5	Ahar/East Azarbaijan	1600	11	Karaj/Alborz	2500
6	Qeinarje/Meshkinshahr/Ardabil	2030	12	Sanandaj/Kordestan	1800

3. RESULTS AND DISCUSSION

Variance analysis of the data indicated that there was a significant difference at %1 probability level,among the populations in all traits under study.(Table 2).On the basis of L.S.D(Least Significant Difference)method, mean comparison was performed at %5 probability level.(Table 3).The populations of Sanandaj with 5019 kg/ha,Goychokhour with 4905 kg/ha,Karaj with 4867 kg/ha,and Qeinarje with 4185 kg/ha forage (Dry Yield) production,received the first to the forth place respectively.Populations of Ahar and Sofian with 3345 kg/ha and 3314 kg/ha respectively,had the lowest Dry Yield.(Table 2,Figure 1).Populations of Goychokhour(163.5),Qeinarje(155),Sanandaj(151),and Karaj (140),had the maximum total tiller number respectively.Populations of Zonouz (75.2) ,Goljar(75.42), and Seyvan - Marand(80.32),had the minimum total tiller number respectively.Regarding plant dry weight,populations of Goychokhour(127.3gr),Karaj(123.45 gr),Sanandaj(123.37 gr) and Qeinarje (109.27 gr),were recognized as the most superior populations respectively.It can be noted that the populations of Goychokhour,Qeinarje,Sanandaj,and Karaj,had superiority over other populations in most of the traits.(Table 3).

Cluster Analysis was done to grouping 12 populations of *Elymus tauri* species from Iran, based on morphological traits mean,using Ward method and Squared Euclidean distance with standard data.[19].The populations of *Elymus tauri* with Cluster Analysis were grouped in two clusters(Figure 2).The populations of Goljar (1600 meter Altitude),Seyvan(1600 meter),Sofian(1700m),Payam(1900m),Ahar(1600m),Zonouz(1400m),Horand(950m) and Jolfa(1200m) were placed in group one.The second group included populations of Qeinarje(2030m, Altitude),Goychokhour(2000m),Sanandaj(1800m)and Karaj(2500m).Such grouping follows dependency and morphological compatibility of the populations from the altitude of primary habitat origins of the seeds(altitude of the seed collection place).

Principal Component Analysis based on morphological traits in *Elymus tauri* species was performed %82.64 of the variance was justified by three Principal Components.(Table 4).The contribution of the first and second components (F1,F2) in variance justification was more than %73.The contribution of the first component in variance justification was %58.43.In explanation of the first component (F1),total tiller number(0.966),fertile tiller number(0.905) and spike length(0.902)traits had high positive and effective roles in population grouping. (table 5).In explanation of the second component(F2),peduncle length (0.796)had a high positive rate.In grouping based on the first and second components(F1,F2)(Figure 3), populations of Goljar,Seyvan,Sofian,Payam,Ahar,Zonouz,Horand and Jolfa were placed in the first group.The second group included populations of Goychokhour,Qeinarje,Karaj,and Sanandaj.This grouping is also confirmed Cluster Analysis results.

Results obtained from variance analysis of the morphological traits showed that there was sufficient genetic diversity among the populations of the species.Therefore,yield improvement can be reached with breeding for improving the mentioned traits.Researchers have reported similar results from their studies on genetic diversity in different species of the *Elymus* and *Agropyron* genera.In a study of genetic diversity in different populations of *Elymus tauri*,Karimzadeh et al.(2012)[14] reported that there was a significant difference among populations,in total tiller number,plant height,leaf number in tiller,flag leaf length, first leaf length,second leaf length,first internode length,second internode length,canopy,plant wet weight,plant dry weight,wet yield and dry yield traits.Farshadfar et al.(2004)[8] investigated genetic diversity in different species of *A.elongatum* using morphological and chemical indices,and reported a significant difference for spike length and plant height traits,while there was no significant difference for tiller number and fertile tiller number.In the study by Jafari et

al.(2011)[11],on genetic diversity in populations of *Agropyron elongatum*,significant difference was observed in plant height,stem number,leaf-stem ratio,peduncle length,leaf number and forage yield traits.In an evaluation of genetic diversity in the populations of *Elymus tauri*,Abdi et al.(2003)[1]reported genetic diversity and significant differences in total tiller number,fertile tiller number,spike length,flag leaf length and plant dry weight traits.Mohammadi et al.(2006)[20]used Factor Analysis for identification of morphological and growth features in *Agropyron elongatum*.They identified three effective factors including forage yield,peduncle length and plant height.Jafari et al.(2010)[11]studied genetic diversity,yield and forage quality in 22 genotypes of *Agropyron elongatum*.Principal Component Analysis showed that the first four components justified %85 of the total variance of the variables.

Table 2.Analysis of Variance for studied traits of *Elymus tauri* populations

Source of variation	Degree of freedom	Means of squares							
		Total tiller number	Fertile tiller number	Non-fertile tiller number	Plant height(cm)	Spike length(cm)	Canopy(cm^2)	PeduncleLength(cm)	flag leaf width(mm)
Replication	3	9.01 ^{ns}	130.33 ^{ns}	73.83*	19.85 ^{ns}	2.36 ^{ns}	30.85^{ns}	7.44 ^{ns}	20.44 ^{ns}
population	11	4404.27**	3658.37**	129.91**	149.79**	50.27**	44.92**	69.63**	167.74**
Error	33	56.7	49.14	19.82	24.57	0.84	26.68	4.92	28.9
Coefficient of variation	-	6.82%	7.67%	23.34%	5.75%	5.46%	7.44%	6.53%	10.28%

Continue Table 2. Analysis of Variance for studied traits of *Elymus tauri* populations

Source of variation	Degree of freedom	Means of squares							
		leaf number in tiller	flag leaf length(cm)	Second leaf length(cm)	Spikelet number	plant wet weight(gr)	plant dry weight(gr)	Wet Yield(kg/ha)	DryYield(kg/ha)
Replication	3	0.04^{ns}	1.15 ^{ns}	2.57 ^{ns}	32.26 ^{ns}	81.15 ^{ns}	478.59 ^{ns}	506350.19 ^{ns}	68713.64 ^{ns}
population	11	1.31**	71.58**	7.37**	106.19**	1297.6**	2903.36**	627930602**	166971.02**
Error	33	0.07	1.51	2.7	5.25	75.84	527.9	391434.17	134300.7
Coefficient of variation	-	6.2%	8.99%	12.7%	11.93%	8.84%	12.21%	8.7%	9.19%

*,**, ns : significant difference at 5 and 1% probability levels respectively , ns: non significant

4. CONCLUSION

There is sufficient genetic diversity in the populations of *Elymus tauri*.Furthermore,due to its high quality forage,it is favored by livestock and is valuable for supplying fodder for rangelands,improving and maintaining rangelands.The hybridization among with geographical distance populations recommended for the benefit of heterosis.

Table 3. Comparisons of mean for studied traits of *Elymus tauri* populations

Population	Total tiller number	Fertile tiller number	Non-fertile tiller number	Plant height(cm)	Spike length (cm)	Canopy (cm^2)	PeduncleLength(cm)	flag leaf width(mm)
Goljar/Marand/East Azarbaijan	75.42	59	16.45	89.92	16.2	737.2	34.85	5.51
Goychokhour/MeshkinshahrArdabil	163.5	135.75	27.75	98.97	25.05	739.2	43.37	5.56
Seyvan /Marand/East Azarbaijan	80.32	63.82	16.5	89.07	14.92	741.5	33.75	5.58
Sofian/East Azarbaijan	94.62	77.8	16.82	83.3	15.62	676.7	33.3	5
Ahar/East Azarbaijan	90.12	78.15	11.97	83.77	15.7	680.7	33.95	4.98
Qeinarje/Meshkinshahr/Ardabil	155	134.1	20.9	85.4	16.95	684.5	35.5	4.99
Payam/Marand/East Azarbaijan	87.1	66.47	20.62	80.02	14	660.2	35.02	4.5
Zonouz/East Azarbaijan	75.2	62.12	13.07	74.17	11.37	628	37.72	3.64
Jolfa/ East Azarbaijan	98	76.85	21.15	84.2	14.25	699.5	25.97	5.82
Horand/ East Azarbaijan	114.4	95.27	19.12	86.67	17.75	689.2	30.97	5.57
Karaj/Alborz	140	109.17	30.82	88.77	19.5	692.7	31.05	5.77
Sanandaj/Kordestan	151	137.8	13.7	90.45	20.22	702.2	32.45	5.8
L.S.D.5%	10.83	10.08	6.41	7.13	1.32	14.3	3.19	0.77

Continue Table 3: Comparisons of mean for studied traits of *Elymus tauri* populations

Populaitons	leaf number in tiller	flag leaf length(cm)	Second leaf length(cm)	Spikelet number	plant wet weight(gr)	plant dry weight(gr)	Wet Yield(kg/ha)	Dry Yield(kg/ha)
Goljar/Marand/East Azarbaijan	4.07	8.32	12.47	13.85	176.2	94.02	5912	3330
Goychokhour/MeshkinshahrArdabil	4.87	16	15.77	26.81	234.88	127.3	8902	4905
Seyvan /Marand/East Azarbaijan	3.55	9.62	11.07	18.3	190.23	98.9	6803	3540
Sofian/East Azarbaijan	3.95	11.32	12.35	17.81	148.73	77.12	7120	3314
Ahar/East Azarbaijan	4.1	11.9	13.12	13.77	162.93	83.65	4782	3345
Qeinarje/Meshkinshahr/Ardabil	4.4	17.2	13.72	29.56	217.98	109.27	7220	4185
Payam/Marand/East Azarbaijan	3.7	11.85	12.55	12.88	167.68	85.65	5811	3715
Zonouz/East Azarbaijan	3.95	8.37	11.72	15.43	173.75	83.12	6422	3466
Jolfa/ East Azarbaijan	4.82	12.17	11.22	14.08	189.3	93.12	8106	4019
Horand/ East Azarbaijan	4.6	17.12	12.72	15.74	166.93	82.57	7841	4150
Karaj/Alborz	5.25	20.5	14.72	19.2	222.03	123.45	8067	4867
Sanandaj/Kordestan	5.2	19.42	13.8	22.82	206.8	123.37	8692	5019
L.S.D.5%	0.39	1.76	2.36	1.146	33.05	12.53	900.07	527.21

Table 4. Percentage of variance of traits accounted for by threecomponents for 12 *Elymus tauri* populations

	F1	F2	F3
Eigenvalue	9.349	2.420	1.455
Variability (%)	58.430	15.127	9.092
Cumulative %	58.430	73.557	82.649

Table 5.Eigen vector of a 3-components for 12 *Elymus tauri* populations

	F1	F2	F3
total tiller number	**0.966**	-0.054	-0.117
fertile tiller number	**0.905**	0.054	-0.032
non-fertile tiller number	0.531	-0.356	-0.306
plant height	0.788	0.401	0.400
spike length	**0.902**	0.187	0.057
canopy	0.303	0.596	0.707
peduncle length	0.319	**0.796**	-0.435
flag leaf width	0.341	0.679	-0.186
leaf number in tiller	0.731	-0.549	0.115
flag leaf length	0.840	-0.410	-0.051
second leaf length	0.820	0.131	-0.482
spikelet numbe	0.821	0.234	-0.122
plant wet weight	0.866	-0.065	0.009
plant dry weight	0.852	-0.132	-0.059
wet yield	0.788	-0.210	0.429
dry yield	0.942	-0.188	0.089

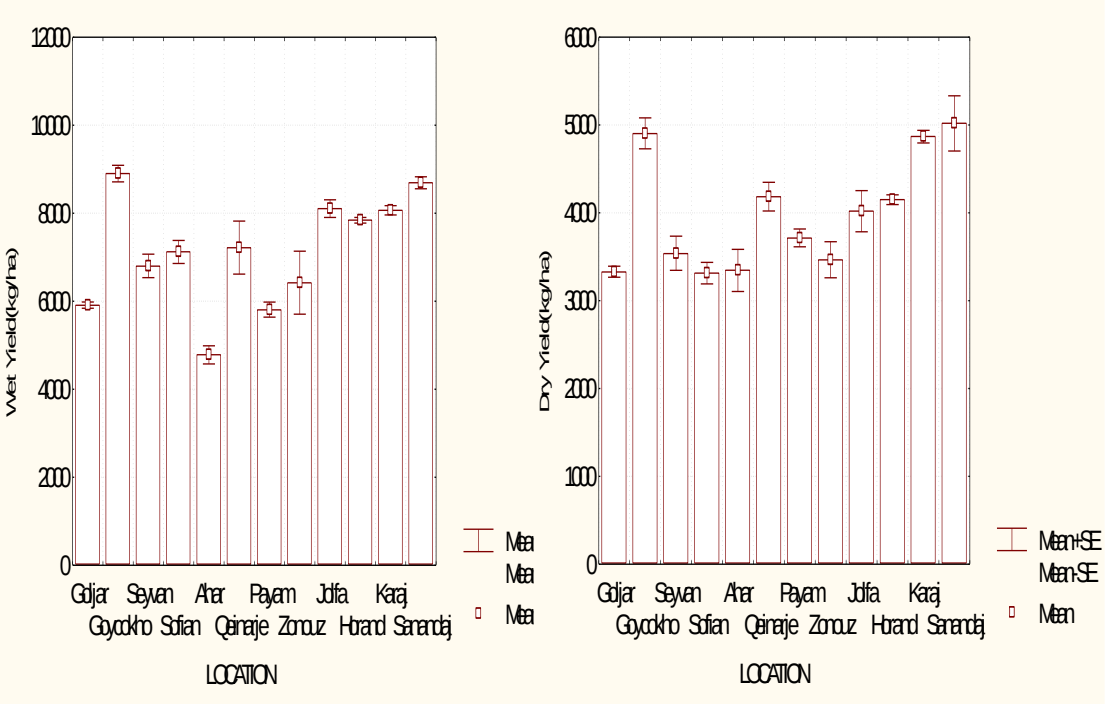

Figure 1. Comparisons of mean for wet yield and dry yield traits of 12 *Elymus tauri* populations

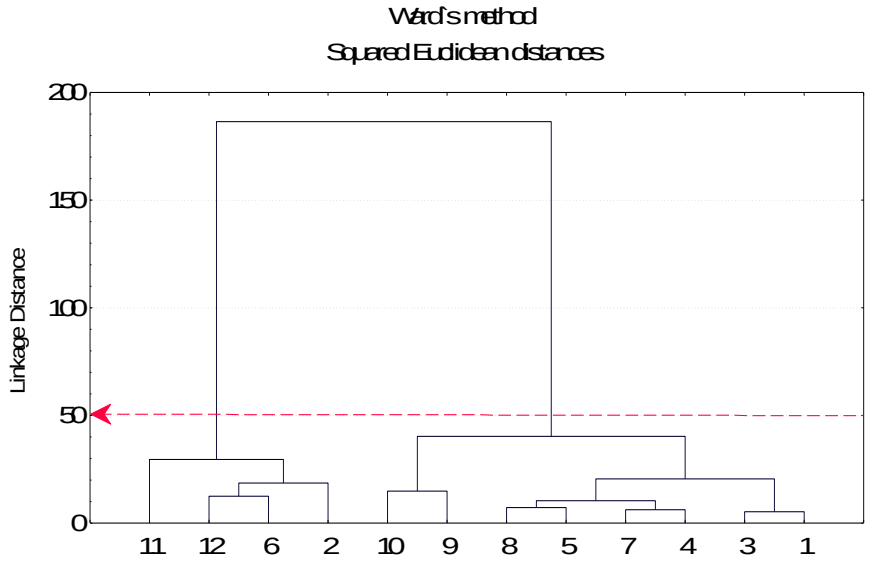

Figure 2. Cluster Analysis of morphological traits based Ward method of 12 *Elymus tauri* populations

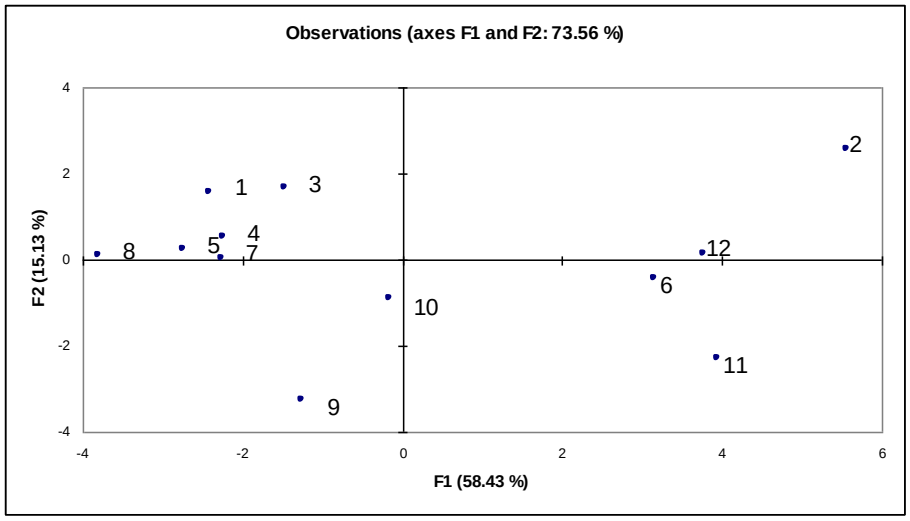

Figure 3.Principal Component Analysis of 12 *Elymus tauri* populations

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