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COMPARISON OF FOLIAR ANATOMY OF TEN BREAD WHEAT (*TRITICUM*, *POACEAE*) AND TEN BARLEY (*HORDEUM*, *POACEAE*) CULTIVARS

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Abstract

The aim of this study is to determine anatomical differences and classification of leaf and leaf cell characteristics (cuticle thickness, upper epidermis thickness, lower epidermis thickness, mesophyll thickness, parenchyma thickness and leaf thickness) between 10 bread wheat cultivars (*Triticum aestivum* L.) and 10 barley cultivars (*Hordeum vulgare* L.). Classification of leaf characteristics in bread wheat and barley cultivars and relationship between leaf characteristics are made by principal component and correlation analyses. Highest thickness belongs to W_8 Müfitbey cultivar in mesophyll and lower epidermis and W_1 Sönmez 01 cultivar have the lowest thickness of upper epidermis in bread wheat. In Barley, B_1 Ince cultivar has highest leaf thickness mesophyll and parenchyma; lowest thickness of cuticle is included B_7 Cumhuriyet 50 cultivar. All other cultivars have homogenous contents of leaf characteristics.

Key words: *Poaceae*, *Triticum*, *Hordeum,* Anatomy, Micro morphology, Classification, PCA, Correlation.

Introduction

Cereals including bread wheat (*Triticum aestivum* L.) and barley (*Hordeum vulgare* L.) are two of the essential crops in the world and hold important and strategic places in many areas such as inputs for home consumption and animal feed, food industry (Ibrahim *et al*., 2013). The needs for bread wheat and barley have been increasing more and more; whereas, crop production hasn't been following the similar trend. Both crops will be more likely the major edible commodity for the billions of people (Anon., 2007, 2009a; Mansing, 2010; Thompson *et al.*, 2010). Plant taxonomy, one of the oldest biological disciplines, is a relevant and important science and taxonomy was based mainly on plant morphology and anatomy (Gilani *et al*., 2002; Krawczyk *et al*., 2013). Family *Gramineae* originates from the Latin word Gramer which was used to be a generic name for certain grasses. However, very recently "International Code of Botanical Nomenclature" has renamed the family Gramineae as family Poaceae, (based upon the type genus *Poa* L.). *Poaceae* a grass family includes about 60 tribes in the world (Davis, 1985) and it is represented by a number of tribes involving many *Triticum* and *Hordeum* species in Turkey (Davis, 1985; Cabi *et al*., 2011; Mavi *et al*., 2011; Zahra *et al*. 2014).

In plant taxonomy, structure and microstructure of leaf are of great significance for classification and identification of plant taxa. Moreover, the leaf anatomy is usually or slightly influenced by the environmental conditions have carried out studies in the field of taxonomy of the leaf (morphological, micro morphological characters of the leaf) of many species (Yousuf *et al*., 2008).

In the present study, the leaves of 10 bread wheat cultivars (*T. aestivum* L.) and 10 barley cultivars (*H. vulgare* L.) were studied by LM in order to assess anatomical variations that may serve as distinguishing characters. On the other hand the present work was undertaken to find out much advanced results on the morphological and micro morphological leaf characters of the bread wheat and barley cultivars. Hence the present study of the leaf with stereo photo Nikon 80i microphotograph microscope will provide new parameters for plant taxonomy and can be valuable additional, diagnostic, systematic and ecologic information. Besides, classification of leaf characteristics of bread wheat and barley cultivars and relationship between leaf characteristics were made by principal component and correlation analyses.

Materials and Methods

This study, was carried out in greenhouse conditions at Eskişehir Osmangazi University, Agricultural College, Eskişehir, Central Anatolia-Turkey (30°32' E-39°46' N, at an altitude of 792 m) in the 2012-2013 cropping seasons. Seeds were sown in PVC containers (0, 75 m width, 1 m length, and 0, 75 m height) containing 80 kg of loamy textured soil (33, 4 % sand, 36, 6 % silt, and 30, 0% clay). Soil also had 0.63% $CaCO_3$, 276, 7 mmol/kg P_2O_5, 304, 3 mmol/kg K_2O, and 2, 44% organic matter, 6, 88 pH, and 3, 12 dS/m electrical conductivity. Bread wheat and barley cultivars were sown during the first two weeks of September at a seed rate of 500 seed/m^2. Sixty kg N ha^{-1} (½ at sowing stage and ½ at tillering stage) and 60 kg ha^{-1} P_2O_5 (at sowing) were applied. Ammonium sulfate (21% N) and triple superphosphate (46% P_2O_5) were used as fertilizers in the study. Normal quality water (EC=1,8-3,1 dS m^{-1}) was selected in the study. Seed of cultivars were sown and allowed to grow until tillering stage in greenhouse, then PVC containers were transferred to ambient conditions. Experimental design was a randomized complete block design (RCBD) with three replications. Containers in the experiment were protected from bird damage by netting. Leaf samples were taken from flag leaves of 10 bread wheat (*T. aestivum* L.) and barley (*H. vulgare* L.) cultivars in flowering stage. Precipitations in 2012-2013 and long term years were 329, 4 mm and 311, 5 mm, respectively. Besides, minimum, maximum and average temperatures were -3, 3°C, 23, 3°C and 9, 9°C in 2012-2013; -8, 3°C, 29, 0°C and 9, 0°C in long term years. Total rainfall in both years was higher than long term periods. Besides, monthly rainfalls in 2012-2013 were higher than long-term years. Ten bread wheat and barley cultivars were used. Bread wheat cultivars; W_1: Sönmez 01, W_2: Alpu 01, W_3: Sultan 95, W_4: Sayer, W_5: Harmankaya, W_6: Altay 2000, W_7: Atay 85, W_8: Müfitbey, W_9: Es 26 and W_{10}: Yunus; barley cultivars; B_1:Ince 04 (two rows), B_2: ClarkxPlaisant (two rows), B_3: PlaisantxKalaycı 97 (two rows), B_4: Avcı 2002 (six row), B_5: Çetin 2000 (six row), B_6: Olgun (six row), B_7: Cumhuriyet 50 (two row), B_8: Ozdemir 05 (two rows), B_9: Kalaycı 97 (two rows) and B_{10}: Plaisant (six rows). The leaf samples were collected during the spring seasons in 2013.

In anatomical studies; flag leaves were fixed in 70% alcohol and then kept in the same solution until taking of transverse sections. For sectioning, samples were taken from the alcohol by hand and scalpel. Totally, in each cultivars; 20 fixed plant samples from healthy flag leaves which obtained from in flowering stage plants were used. The sections were photographed by the Kameram™ digital camera and a Nikon 80i type microscope in Eskişehir Osmangazi University, Faculty of Science and Letters Department of Biology. A variety of foundation anatomical books and conducted studies were used as sources for identification of the plants (Esau, 1965; Fahn, 1967; Vardar, 1987; Özörgücü *et al.*, 1991; Yentür, 1995). All measurements and counts have been performed on slides made from 20 samples of each cultivar. Descriptive analysis of the data, Principle Component and Correlation Analyses were performed using the soft-ware package STATISTICA 10.0 (Jambu, 1991; Otto, 1999; Hiltbrunner *et al.*, 2007).

Result and Discussion

A number of bread wheat and barley cultivars grown in the world show large differences under wide range of environmental conditions. Some of cultivars are well adapted to a wide range of varying and some are grown locally. Adaptability of bread wheat and barley is so important since cultivars, well adapted; having large number of morphological and genotypic differences will help to increase usability, profitableness of the cultivars (Ivancevic *et al.*, 2000). The identification of cultivars requires some knowledge of the morphological appearance of plant. Practical and usable classifications are required to standardize the varietal nomenclature (Khan & Tsunoda, 1971; Murphy *et al.,* 2007). Anatomic studies in *Gremineae* were well made and they were found as important in determination of structure, function and comparison of characteristics in varieties/cultivars (Mavi *et al.*, 2011). Determining differences in bread wheat and barley cultivars could be made by presenting genotypic, physiological and morphological characteristics. One of the differences is difference in foliar characteristics (Adhikary *et al.*, 2007; Özler *et al.,* 2009; Cabi *et al.,* 2010).

Foliar differences in bread wheat (*T. aestivum* L.): Minimum, maximum and means in characteristics of cuticle, upper epidermis, lower epidermis, mesophyll, parenchyma and leaf thickness in bread wheat are given in Table 1.

Leaf thickness: The thickness of flag leaf of the examined 10 bread wheat cultivars vary between 164,52-357,14 µm at mid-lamina; [W_1 (357,14 µm), W_2 (197,14 µm), W_3 (185,37 µm), W_4 (205,13 µm), W_5 (164,52 µm), W_6 (242,86 µm), W_7 (211,77 µm), W_8 (285,71 µm), W_9 (235,26 µm), and W_{10} (242,42 µm)] and arms of the lamina symmetrical in all cultivars. W_1 (357,14 µm) has the thick leaf and W_5 (164,52 µm) has the thin leaf.

Cuticle: Thickness of cuticle of the examined 10 bread wheat cultivars vary between 3,43-7,86 µm; [W_1 (3,92 µm), W_2 (3,43 µm), W_3 (4,88 µm), W_4 (5,38 µm), W_5 (3,87 µm), W_6 (3,57 µm), W_7 3,53 µm), W_8 (7,86 µm), W_9 (7,15 µm), and W_{10} (6,64 µm)]. W_8 (7,86 µm) has the thick cuticle and W_2 (3,43 µm) has the thin cuticle.

Upper epidermis thickness: Thickness of upper epidermis of the examined 10 bread wheat cultivars vary between 23,08-39,29 µm; [W_1 (28,61 µm), W_2 (22,86 µm), W_3 (29,27 µm), W_4 (23,08 µm), W_5 (38,71 µm), W_6 (28,57 µm), W_7 (32,35 µm), W_8 (35,71 µm), W_9 (39,29 µm), and W_{10} (30,30 µm)]. W_9 (39,29 µm) has the thick upper epidermis and W_4 (23,08 µm) has the thin upper epidermis.

Lower epidermis thickness: Thickness of lower epidermis of the examined 10 bread wheat cultivars vary between 21,95-42,86 µm; [W_1 (28,64 µm), W_2 (31,42 µm), W_3 (21,95 µm), W_4 (25,64 µm), W_5 (25,81 µm), W_6 (35,71 µm), W_7 (26,47 µm), W_8 (42,86 µm), W_9 (32,14 µm), and W_{10} (33,33 µm)]. W_8 (42,86 µm) has the thick upper epidermis and W_1 (21,95 µm) has the thin lower epidermis.

Mesophyll thickness: Thickness of mesophyll of the examined 10 bread wheat cultivars vary between 117,07-221,43 µm; [W_1 (207,10 µm), W_2 (131,43 µm), W_3 (117,07 µm), W_4 (158,97 µm), W_5 (154,84 µm), W_6 (164,29 µm), W_7 (152,94 µm), W_8 (221,43 µm), W_9 (185,71 µm), and W_{10} (187,89 µm)]. W_8 (221,43 µm) has the thick mesophyll and W_3 (117,07 µm) has the thin mesophyll.

Parenchyma cell thickness: Thickness of parenchyma cell of the examined 10 bread wheat cultivars vary between 29,27-75,13 µm; [W_1 (75,13 µm), W_2 (51,43 µm), W_3 (29,27 µm), W_4 (48,72 µm), W_5 (35,48 µm), W_6 (42,87 µm), W_7 (29,41 µm), W_8 (64,26 µm), W_9 (64,29 µm), and W_{10} (33,33 µm)]. W_1 (75,13 µm) has the thick parenchyma cell and W_3 (29,27 µm) has the thin parenchyma cell. Besides, appearances of leaf cross sections are seen in Fig. 1.

Foliar differences in barley (*H. vulgare* L.): Minimum, maximum and means in characteristics of cuticle, upper epidermis, lower epidermis, mesophyll, parenchyma and leaf thickness in barley are given in Table 2.

Table 1. Minimum, maximum and means in leaf characteristics of bread wheat.

Variables	Minimum	Maximum	Mean
Leaf thickness	164,52	357,14	232,73 ± 55,63
Cuticle	3,43	7,86	5,03 ± 1,66
Upper epidermis	22,86	39,29	30,87 ± 5,74
Lower epidermis	21,95	42,86	30,40 ± 6,05
Mesophyll	117,07	221,43	168,17 ± 32,52
Parenchyma	29,27	75,13	47,41 ± 16,22

Table 2. Minimum, maximum and means in leaf characteristics of barley.

Variables	Minimum	Maximum	Mean
Cuticle	3,93	7,41	5,43 ± 1,19
Upper epidermis	20,00	34,48	26,99 ± 4,36
Lower epidermis	18,92	37,04	27,22 ± 6,51
Mesophyll	111,43	223,33	157,51 ± 34,33
Parenchyma	20,00	74,44	33,91 ± 15,40
Leaf thickness	148,58	282,66	198,45 ± 39,92

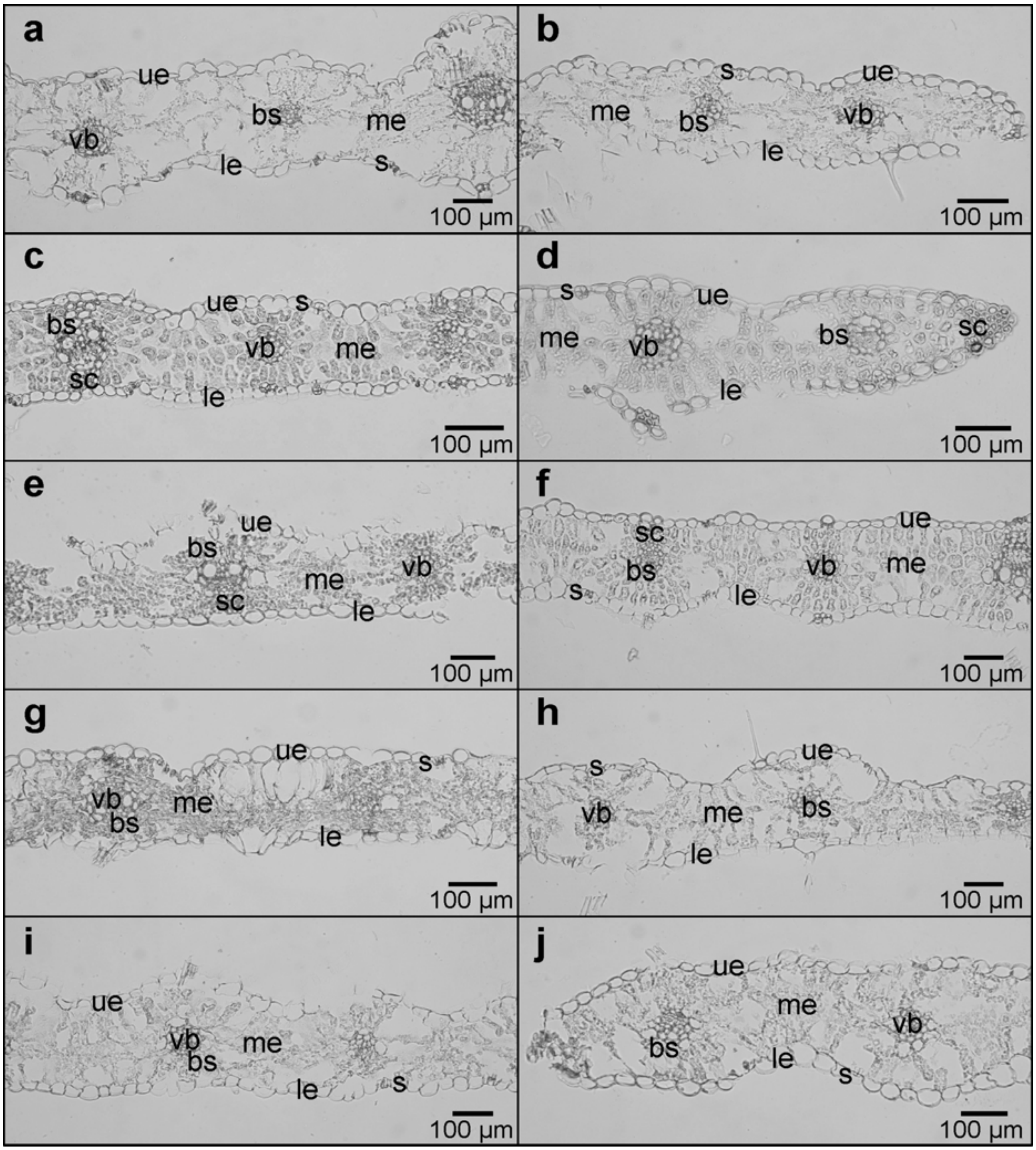

Fig. 1. Leaf cross sections of the examined bread wheats leaf. a: Sönmez 01 (W_1), b: Alpu 01 (W_2), c: Sultan 95 (W_3), d: Sayer (W_4), e: Harmankaya (W_5), f: Altay 2000 (W_6), g: Altay 85 (W_7), h: Müfitbey (W_8), i: Es 26 (W_9), j: Yunus (W_{10}) (ue: upper epidermis, le: lower epidermis, s: stoma, vb: vascular bundle, bs: bundle sheath, me: mesophyll, sc: sclerenchyma)

Leaf thickness: The thickness of flag leaf of the examined 10 barley vary between 148,58-282,66 µm at mid-lamina; [B_1 (282,66 µm), B_2 (208,82 µm), B_3 (221,43 µm), B_4 (156,25 µm), B_5 (225,93 µm), B_6 (148,58 µm), B_7 (189,66 µm), B_8 (176,47 µm), B_9 (167,57 µm), and B_{10} (207,14 µm)] and arms of the lamina symmetrical in all cultivars. B_1 (282,66 µm) has the thick leaf and B_6 (148,58 µm) has the thin leaf.

Cuticle: Thickness of cuticle of the examined 10 barley cultivars vary between 3,93-7,41 µm; [B_1 (4,00 µm), B_2 (5,29 µm), B_3 (4,29 µm), B_4 (3,93 µm), B_5 (7,41 µm), B_6 (5,14 µm), B_7 (6,90 µm), B_8 (6,18 µm), B_9 (5,14 µm), and B_{10} (6,07 µm)]. B_5 (7,41 µm) has the thick cuticle and B_4 (3,93 µm) has the thin cuticle.

Upper epidermis thickness: Thickness of upper epidermis of the examined 10 barley cultivars vary between 20,00-34,48 µm; [B_1 (26,67 µm), B_2 (26,47 µm), B_3 (28,57 µm), B_4 (28,13 µm), B_5 (26,63 µm), B_6 (20,00 µm), B_7 (34,48 µm), B_8 (32,35 µm), B_9 (21,62 µm), and B_{10} (25,00 µm)]. B_7 (34,48 µm) has the thick upper epidermis and B_6 (20,00 µm) has the thin upper epidermis.

Lower epidermis thickness: Thickness of lower epidermis of the examined 10 barley cultivars vary between 18,92-37,04 µm; [B_1 (36,67 µm), B_2 (26,47 µm), B_3 (21,43 µm), B_4 (25,00 µm), B_5 (37,04 µm), B_6 (22,86 µm), B_7 (34,48 µm), B_8 (23,53 µm), B_9 (18,92 µm), and B_{10} (25,89 µm)]. B_5 (37,04 µm) has the thick upper epidermis and B_9 (18,92 µm) has the thin lower epidermis.

Mesophyll thickness: Thickness of mesophyll of the examined 10 barley cultivars vary between 111,43-223,33 µm; [B_1 (223,33 µm), B_2 (167,64 µm), B_3 (185,72 µm), B_4 (121,88 µm), B_5 (177,78 µm), B_6 (111,43 µm), B_7 (137,93 µm), B_8 (141,76 µm), B_9 (132,43 µm), and B_{10} (175,23 µm)]. B_1 (223,33 µm) has the thick mesophyll and B_6 (111,43 µm) has the thin mesophyll.

Parenchyma cell thickness: Thickness of parenchyma cell of the examined 10 barley cultivars vary between 20,00-74,44 µm; [B_1 (74,44 µm), B_2 (26,47 µm), B_3 (39,29 µm), B_4 (25,00 µm), B_5 (37,04 µm), B_6 (20,00 µm), B_7 (31,03 µm), B_8 (29,41 µm), B_9 (24,32 µm), and B_{10} (32,15 µm)]. B_1 (74,44 µm) has the thick parenchyma cell and B_6 (20,00 µm) has the thin parenchyma cell. Besides, appearances of leaf cross sections are seen in Fig. 2.

Principle Component and Correlation Analyses on foliar characteristics in bread wheat (*T. aestivum* L.) and barley (*H. vulgare* L.): Bread wheat and barley having economic importance are splendid crops for genetically, morphological and physiological studies (Ivancevic *et al.*, 2000; Anon., 2008, 2009b). Mohammadi & Prasanna (2003) stated assessment of plants in terms of morphological characteristics is main breeding objective and could be well defined by principal component analysis. Classifications are well performed by principal component and classification analysis that could be used to identify and to map into dimensions among characters, to determine clusters of variables with similar characteristics (Mohammadi & Prasanna, 2003). Aim of principal component and classification analysis is to determine certain factors, and to explain correlations in variable data. It is often used in data reduction to determine small number of factors explaining most of the variance (Mohammadi & Prasanna, 2003). It could be said that the higher value of the factor loading of a variable on a particular factor, the more significantly is the variable related to that factor.

In bread wheat, eigenvalues and total variances explaining similarities/dissimilarities in bread wheat cultivars are given in Table 3. Variables in the factorial plane (Table 4) shows the first factor corresponding to the largest eigenvalue (3,33) accounts for approximately 55,43% of the total variance. The second factor corresponding to the second eigenvalue (1,28) accounts for approximately 21,40% of the total variance, and so on. The first two factors occupying 76,84% of total variance explains to interpret variances in leaf characteristics and cultivars. Factor coordinates of the leaf characters, based on correlations in bread wheat cultivars are seen in Table 5 and Fig. 3. Mesophyll (-0,96) and lower epidermis (-0,88) in the first PC, upper epidermis (-0,78) in the second PC have highest contribution (Table 5 and Fig. 3). Moreover, factor coordinates of cultivars, based on correlations are given in Table 6. Similarly, total variability of the first component is influenced by W_1 Sönmez 01 (-1,90), W_3 Sultan 95 (2,36) and W_8 Müfitbey (-3,38). Figure 3 also showed that total variability of the second component was influenced mostly by W_5 Harmankaya (-1,34). Principal component analysis is be able to differ bread wheat cultivars. It could be said that and W_8 Müfitbey cultivar has highest thickness of mesophyll and lower epidermis while the lowest thickness of upper epidermis belonged to W_1 Sönmez 01 cultivar (Fig. 3). Correlation analysis is widely used in statistical evaluations and it shows efficiency of relationship between two variables. Correlations approaching 1 assign that almost similar results are taken from two variables. On the contrary, correlations approaching to -1 show that opposite results occur in two characters. (Hiltbrunner *et al.*, 2007). Correlation matrix for leaf characters of wheat cultivars are given in Table 6. Relationship between cuticle and mesophyll, cuticle and parenchyma, mesophyll and lower epidermis and leaf thickness and parenchyma are found as positive and significant at 5%; only relationship between leaf thickness and mesophyll is determined as positive and significant ($p<0,01$).

In barley, similarities/dissimilarities are revealed by eigenvalues and total variances are shown in Table 7. The first factor assigning the largest eigenvalue (3,35) accounts for approximately 55,84% of the total variance. The second factor giving the second eigenvalue (1,53) accounts for almost 25,58% of the total variance. Having 81,43% of total variance, Factor I and II denote variances in leaf characteristics and cultivars. Correlation based factor coordinates of leaf characters in bread wheat cultivars are seen in Table 8 and Fig. 4. Mesophyll (-0,93), parenchyma (-0,94) and leaf thickness (-0,98) in the first PC, cuticle (0,88) in the second PC have highest contribution (Table 5 and Fig. 4). Moreover, factor coordinates of cultivars, based on correlations are given in Table 9. B_1 Ince (-4,05), B_6 Olgun (2,34) and B_9 Kalaycı (1,82) affect total variability of the first component. Figure 4 also showed that total variability of the second component was influenced mostly by B_5 Çetin 2000 (1,50) and B_7 (2,35). B_1 Ince cultivar has highest leaf thickness mesophyll and parenchyma; B_7 Cumhuriyet 50 cultivar has the lowest thickness of cuticle (Fig. 4). Correlation matrix of leaf characters in barley cultivars are given in Table 10. Relationship between lower epidermis and parenchyma, leaf thickness and parenchyma are determined as positive and significant ($p<0,05$); while relationship between leaf thickness and cuticle, parenchyma and mesophyll, leaf thickness and upper epidermis were found as positive and significant at 1%.

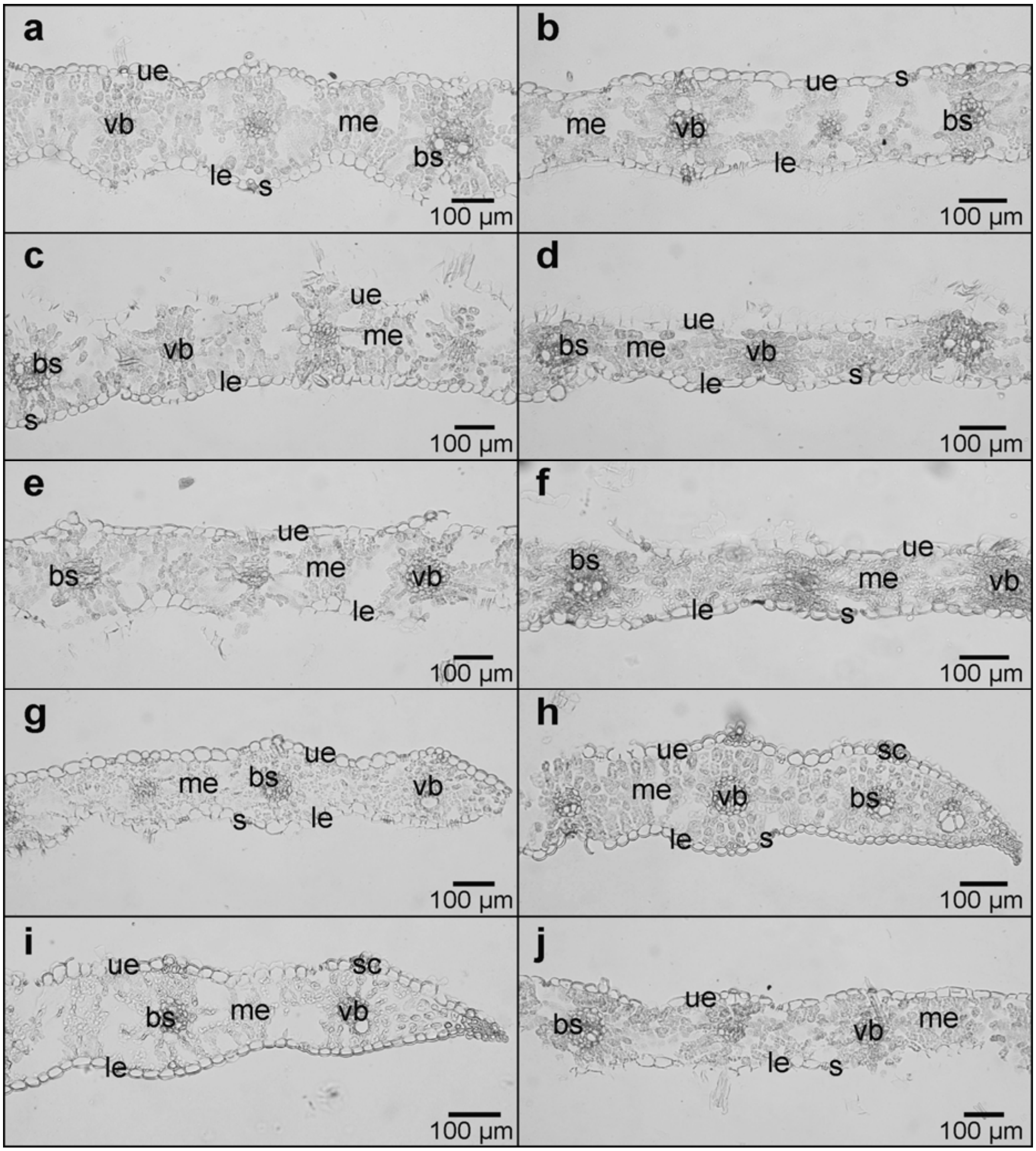

Fig. 2. Leaf cross sections of the examined barley leaf. a:Ince (B_1), b: ClarkxPlaisant (B_2), c: PlaisantxKalaycı (B_3), d: Avcı 2002 (B_4) e: Çetin 2000 (B_5), f: Olgun (B_6), g: Cumhuriyet 50 (B_7), h: Ozdemir 05 (B_8), i: Kalaycı (B_9), j: Plaisant (B_{10}) (ue: upper epidermis, le: lower epidermis, s: stoma, vb: vascular bundle, bs: bundle sheath, me: mesophyll, sc: sclerenchyma).

Table 3. Eigenvalues and total variances in bread wheat cultivars.

Value number	Eigenvalue	Total variance %	Cumulative eigenvalues	Cumulative %
1	3,33	55,43	3,33	55,43
2	1,28	21,40	4,61	76,84
3	0,62	10,34	5,23	87,18
4	0,42	7,04	5,65	94,22
5	0,29	4,76	5,94	98,97
6	0,06	1,03	6,00	100,00

Table 4. Factor coordinates of the characters, based on correlations in bread wheat cultivars.

Characters	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6
Leaf thickness	-0,80	0,49	0,19	-0,03	-0,26	-0,14
Cuticle	-0,66	-0,52	-0,33	0,43	-0,07	-0,05
Upper epidermis	-0,36	***-0,78***	0,49	-0,14	0,07	-0,05
Lower epidermis	***-0,88***	-0,10	-0,44	-0,41	0,14	-0,04
Mesophyll	***-0,96***	-0,01	0,09	-0,05	-0,20	0,19
Parenchyma	-0,78	0,40	0,18	0,21	0,39	0,01

Table 5. Factor coordinates of cultivars, based on correlations in bread wheat.

Varieties	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6
$\mathbf{W_1}$ Sönmez 01	-1,90	2,16	1,27	0,19	-0,31	-0,04
$\mathbf{W_2}$ Alpu 01	1,32	1,20	-0,79	-0,24	0,89	-0,04
$\mathbf{W_3}$ Sultan 95	***2,36***	-0,40	-0,01	0,70	-0,22	-0,48
$\mathbf{W_4}$ Sayer	0,86	0,72	-0,63	1,01	-0,02	0,43
$\mathbf{W_5}$ Harmankaya	1,37	***-1,34***	1,05	-0,43	0,28	0,32
$\mathbf{W_6}$ Altay 2000	0,12	0,58	-0,41	-1,14	0,05	-0,10
$\mathbf{W_7}$ Atay 85	1,44	-0,26	0,50	-0,54	-0,47	0,01
$\mathbf{W_8}$ Müfitbey	***-3,38***	-0,77	-0,68	-0,21	0,12	-0,04
$\mathbf{W_9}$ Es 26	-1,62	**-1,24**	0,53	0,63	0,64	-0,13
$\mathbf{W_{10}}$ Yunus	-0,56	-0,66	-0,83	0,02	-0,96	0,07

Table 6. Correlation matrix for leaf characters of bread wheat cultivars.

	Cuticle	Upper epidermis	Lower epidermis	Mesophyll	Paranchyma
Upper epidermis	0,415ns				
Lower epidermis	0,521ns	0,210ns			
Mesophyll	0,584*	0,379ns	0,690*		
Paranchyma	0,677*	0,307ns	0,055	0,455ns	
Leaf thickness	0,220ns	-0,008ns	0,468ns	0,803**	0,748*

ns: No-significant; *: Significant at 5%; **: Significant at 1%

Table 7. Eigenvalues and total variances in barley cultivars.

Value number	Eigenvalue	Total variance %	Cumulative eigenvalues	Cumulative %
1	3,35	55,84	3,35	55,84
2	1,53	25,58	4,88	81,43
3	0,71	11,79	5,59	93,21
4	0,33	5,53	5,92	98,74
5	0,07	1,19	5,99	99,93
6	0,004	0,07	6,00	100,00

Table 8. Factor coordinates of the leaf characters, based on correlations in barley cultivars.

Characters	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6
Cuticle	0,03	***0,88***	-0,42	-0,21	0,09	0,00
Upper epidermis	-0,29	0,66	0,69	-0,08	-0,01	0,00
Lower epidermis	-0,75	0,47	-0,19	0,41	-0,09	-0,01
Mesophyll	***-0,93***	-0,20	-0,07	-0,29	-0,08	-0,04
Parenchyma	***-0,94***	-0,24	0,07	0,12	0,21	-0,01
Leaf thickness	***-0,98***	-0,12	-0,08	-0,14	-0,05	0,05

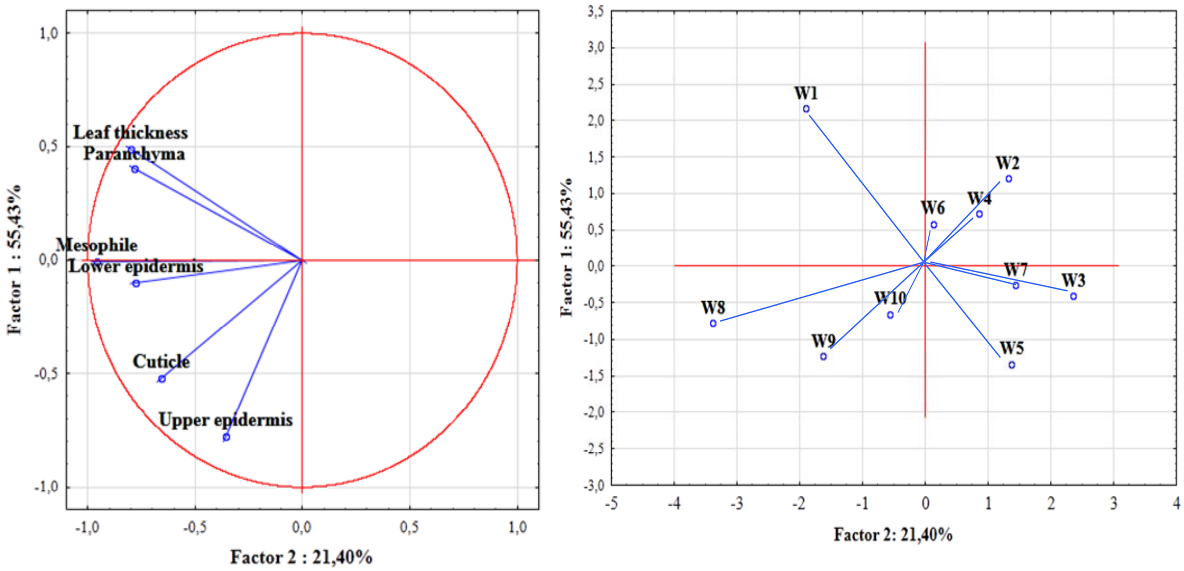

Fig. 3. Rotated principal component loadings (leaf characteristics of bread wheat) and rotated principal component scores for cultivars in bread wheat.

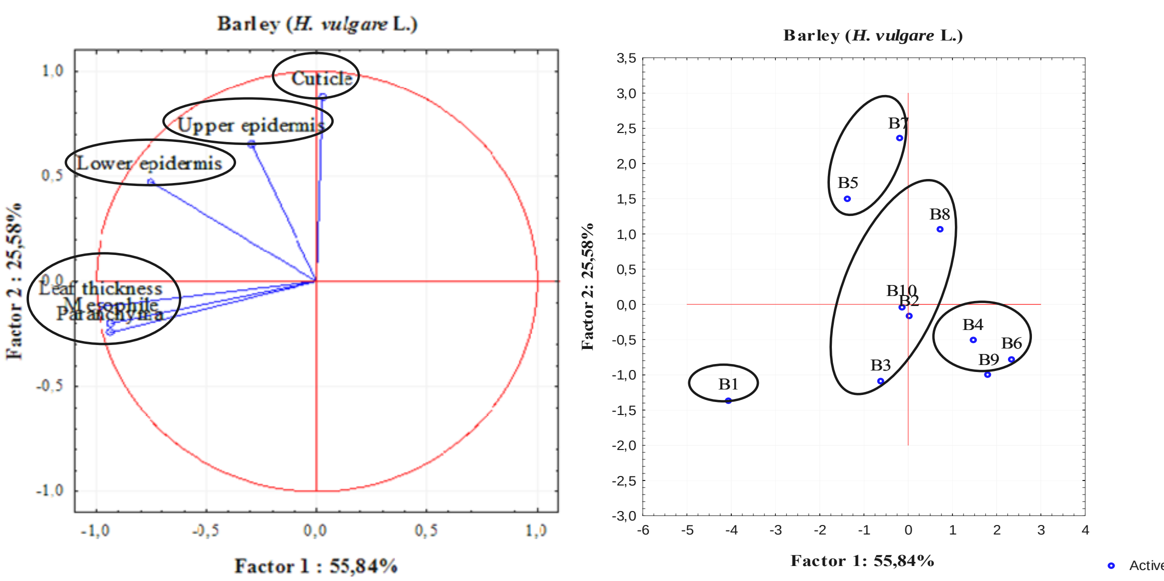

Fig. 4. Rotated principal component loadings (leaf characteristics of barley) and rotated principal component scores for cultivars in barley.

Table 9. Factor coordinates of cultivars, based on correlations in barley.

Varieties	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6
B_1 Ince	***-4,05***	-1,36	0,09	0,57	0,21	0,01
B_2 ClarkxPlaisant	0,02	-0,17	-0,10	-0,33	-0,52	0,08
B_3 PlaisantxKalaycı	-0,61	-1,08	0,89	-0,79	-0,10	0,02
B_4 Avcı 2002	1,47	-0,50	1,05	0,84	-0,26	-0,09
B_5 Çetin 2000	-1,35	***1,50***	-1,33	0,05	-0,12	-0,04
B_6 Olgun	***2,34***	-0,77	-0,90	0,61	0,12	0,02
B_7 Cumhuriyet 50	-0,21	***2,35***	0,60	0,40	0,04	0,07
B_8 Ozdemir 05	0,72	1,06	0,89	-0,49	0,38	-0,03
B_9 Kalaycı	***1,82***	-1,00	-0,53	-0,23	0,27	0,07
B_{10} Plaisant	-0,15	-0,03	-0,66	-0,62	-0,02	-0,11

Table 10. Correlation matrix for leaf characters of barley cultivars.

	Cuticle	Upper epidermis	Lower epidermis	Mesophyll	Paranchyma
Upper epidermis	0,291ns				
Lower epidermis	0,381ns	0,371ns			
Mesophyll	-0,116ns	0,119ns	0,512ns		
Paranchyma	-0,274ns	0,157ns	0,606*	0,862**	
Leaf Thickness	0,981**	0,908**	-0,072	0,166	0,641*

ns: No-significant; *: Significant at 5%; **: Significant at 1%

Studies are commonly dealt with differences between leaf characteristics and leaf dimensions. Differences of leaf characteristics are mostly depend upon varied genotypic capacity, different environmental factors and agronomic applications (Dornbusch *et al.,* 2011). Not only anatomic characteristics of leaf determine their features/differences in genotypes, but it is also assign genotypic performance such as photosynthetic rate that is so vital for better yield performance. Besides, mesophyll cell size and intercellular space have effect on photosynthetic rate that related to other morphologic and physiologic characters (Garcia de Moral *et al.,* 2003). Moreover, decrease in mesophyll cell size increases specific leaf weight and cell number/cm² and rates of photosynthesis. Size or thickness of cells is under the effect of environmental changes and significant differences (Khan & Tsunoda 1971; Jellings & Leech 1984; Akram *et al.*, 2002). Similarly cell thickness significantly differed not only between different cell groups but also plant species (Treshow, 1970; Mooney & Gulmon, 1979), mesophyll thickness particularly showed significant changes between different species under water stress (Mooney & Gulmon, 1979). Classifications of physiologic characters by principal component analysis have been made to reveal similarities/dissimilarities of characters (Arduini *et al*., 2006; Garcia de Moral *et al.,* 2003). Mavi *et al.* (2011) reported that a number of anatomic characters are different from each other in length/width or diameter in genus of *Agropyron* L. Jellings & Leech (1984) reported that cell size is mainly related to cell number that is different in cultivars in *Triticum* genus. Successful breeding programs and seed production organizations necessitate usage and production of pure seed. Cultivars should be sorted by genotypic, morphological and biochemical characteristics (El-Afry *et al.*, 2012) so, determination of leaf characteristics of cultivars are effective method for separating and classifying of cultivars (Rajput *et al.*, 1996). The morphological characterization studies comprise to study the whole plant characterization or seed. So, different cultivars could be identified by characterization (Adhikary *et al.*, 2007; Sack & Scoffoni, 2013; Akram *et al.*, 2002).

It could be said that highest thickness belongs to W_8 Müfitbey cultivar in mesophyll and lower epidermis and W_1 Sönmez 01 cultivar have the lowest thickness of upper epidermis in bread wheat. In Barley, B_1 Ince cultivar has highest leaf thickness mesophyll and parenchyma; lowest thickness of cuticle is included B_7 Cumhuriyet 50 cultivar. All other cultivars have homogenous contents of leaf characteristics. The results of this study could lead to a better understanding of the cultivars and provide a contribution to any future studies.

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