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Research Article

Morphological Characterization of *A. vineale*

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Abstract: *Allium vineale* L. is a wild edible *Allium* species. This species is collected from nature by the local people in the Eastern Anatolia Region of Turkey and consumed as a vegetable. Aboveground organs of *A. vineale* plants are used in herbed cheese production in the eastern provinces. Collection from nature is not a sustainable way production of this species. *A. vineale* can be propagated via seeds and bulbils. It is suitable for cultivation under field and protected conditions. For agricultural production of this species, new cultivars with improved yield and quality traits have to be developed. In this study, an *A. vineale* germplasm was created with the aim of developing new cultivars that can be used in herbed cheese production. The accessions included in the germplasm were characterized for desired traits such as adaptability to culture conditions, agronomic characteristics and harvest uniformity. The phenotypic diversity of *A. vineale* accessions were examined using morphological descriptors derived from International Union for the protection of New Varieties of Plants (UPOV). According to the clustering and principal coordinate analysis (PCoA) made by evaluation of the morphological features, the accessions were divided into two main groups based on the locations. Germplasm accessions differ from each other for leaf waxiness and color intensity. *A. vineale* can be distinguished from other *Allium*s present in the same area with thin leaves, short plant height, and multiple bulbils in the flower scapes.

A. vineale'nin Morfolojik Karakterizasyonu

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Anahtar Kelimeler

Fenotipik çeşitlilik,
Sirmo,
UPOV,
UPGMA,
Yabani sarımsak.

Öz: *Allium vineale* L. yenilebilir bir yabani *Allium* türüdür. Bu tür Türkiye'nin Doğu Anadolu Bölgesi'nde yerel insanlar tarafından doğadan toplanarak sebze olarak tüketilmektedir. *A. vineale* bitkilerinin toprak üstü organları doğu şehirlerinde otlu peynir üretiminde kullanılmaktadır. Doğadan toplamak bu türün üretimi için sürdürülebilir bir yol değildir. *A. vineale* tohumlar ve bulbiller ile çoğaltılabilmektedir. Arazi ve korunmuş yapılar içerisinde yetiştiriciliğe uygundur. Tarımsal üretim için arttırılmış verim ve kalite özellikleri yeni çeşitlerin geliştirilmesine ihtiyaç vardır. Bu çalışmada, otlu peynir üretiminde kullanılabilecek yeni çeşitlerin geliştirilmesi amacına yönelik olarak bir *A. vineale* genetik havuzu oluşturulmuştur. Bu genetik havuzda yer alan aksesyonlar kültür koşullarına adaptasyon, agronomik özellikler ve hasat uniformitesi gibi tercih edilen özellikler için karakterize edilmişlerdir. *A. vineale* aksesyonlarının fenotipik çeşitliliği International Union for the protection of New Varieties of Plants (UPOV) tarafından belirlenmiş morfolojik tanımlamalarla değerlendirilmiştir. Morfolojik özellikler değerlendirilerek yapılan kümeleme ve temel koordinat (PCoA) analizlerine göre aksesyonlar lokasyona bağlı olarak iki ana guruba ayrılmıştır.

Genetik havuzdaki aksesyonlar yaprak mumsuluğu ve renk yoğunluğu yönünden birbirlerinden farklılık göstermişlerdir. *A. vineale*, ince yaprakları, kısa bitki boyu ve çiçek umbelinde bulunan fazla sayıda topset ile aynı alanda bulunan diğer Allium türlerinden ayırt edilebilir nitelik taşımaktadır.

1. Introduction

Local plant germplasm created at various ecological regions produce genetic material for new plant varieties and accelerate breeding studies. In this respect, the UPOV (International Union for the Protection of New Varieties of Plants) center was established in Geneva (Switzerland) with an international agreement in 1961 for the protection of new plant varieties in the world. The mission of UPOV is to provide and promote an effective system of plant diversity conservation with the aim of promoting the development of new plant varieties for the benefit of society. Descriptors for edible *Allium* species and *A. schoenoprasum* L. have been applied by UPOV (2014). Many studies on the morphological characterization of *Allium* species have been carried out (Nomura and Makara, 1996; Friesen et al., 2000; Polyzos et al., 2019; Şelem et al., 2020).

Allium vineale L., a wild species with garlic-like taste, is found naturally on dry fields in Europe, on Swedish coastlines, in the steppe-like grasslands of the Baltic islands and high-altitude wetlands with continental climate and in the meadows in Turkey (Satyal et al., 2017). The leaves and bulbs of *A. vineale* are used as food in place of *A. sativum*. Native Americans use both *A. vineale* and *A. sativum* as a carminative, diuretic and expectorant (Satyal et al., 2017). Moreover, *A. vineale* known as a weed (Ceplitis, 2001), ornamental plant (Sansford et al., 2015) or medical agent (Stajner et al., 2006) is collected from nature in the Eastern Anatolia region of Turkey and it is consumed widely by local people as a spice or fresh in herbed cheese (Güldigen and Şensoy, 2015; Güldigen and Şensoy, 2016; Eryiğit et al., 2020). Moreover, *A. vineale* increases the nutritional quality of herbed cheese thanks to its high antioxidant and antimicrobial bioactive constituents and it contributes to the ripening process and keeping the cheese fresh for a long time (Coşkun and Oztürk, 2000; Dagdelen et al, 2014; Guldigen and Sensoy, 2016). This plant species has not been previously defined morphologically according to the UPOV morphological traits.

In the present study, morphological characterization of *A. vineale* accessions collected from different locations within the borders of Van province was carried out according to guidelines of UPOV. The major aim of the project was to characterize the accession collection to determine genetic diversity and potential use in breeding programs.

2. Materials and Methods

2.1. Plant materials and growing conditions

The whole plants were collected from 10 different locations in Van province between 20 May and 5 June in 2018. Plants with bubs were transplanted in 3-liter pots with a 2:1 mixture of peat: perlite medium and placed in a greenhouse of Horticulture Department of Van Yuzuncu Yil University (Table 1 and Figure 1). Fertilization and irrigation were carried out according to normal cultivation practices for garlic. Identification of the species was made during flowering period in Biology Department of Van Yuzuncu Yil University.

Table 1. The locations and coordinates of the *A. vineale* accessions collected

Accession	Locations	Coordinates	Altitude (m)
L-1	Lake Kesis (Turna)-Gurpinar/VAN	38°27'36.12" K 43°35'07.80" D	2555 ±5
L-2	Derebey- Pirgarip village -Tusba/VAN	38°46' 26.76"K 43° 28'45.14"D	2005 ±5
L-3	Akcift village-Tusba/VAN	38°49'29.92" K 43°33'37.52" D	2390 ±5
L-4	Sehirpazar village-Ercis/VAN	39°14'05.98" K 43° 25'14.24"D	2245 ±5
L-5	Altiyol village-Caldiran/VAN	39°05'03.83" K 43° 58'52.01"D	2040 ±5
L-6	Yumruklu village-Baskale/VAN	38°50'11.11" K 44° 04'53.43"D	2025 ±5
L-7	Kecilioba village-Baskale/VAN	37°52'17.93" K 43°56'31.92" D	2290 ±5
L-8	Kirkgecit village (Norduz) Gurpinar/VAN	38°06'51.60" K 43°22'10.67" D	2450 ±5
L-9	Derebası village-Catak/VAN	38°11'04.87" K 43°13'00.94" D	2180 ±5
L-10	Timar village-Gevas/VAN	38°24'38.86" K 42°49'46.13" D	2075 ±5

Figure 1. Plotting of locations on the map (Google Earth).

2.2. Morphological traits measurement

The morphological characteristics of the collected accessions were determined according to guidelines set by the International Union for Conservation of New Plant Varieties on January 24, 2014, with the code TG/198/2 (PROJ.4) for the *A. schoenoprasum* (UPOV, 2014). A total of 12 morphological characters were examined. For morphological observations in the experiment, 10 randomly selected plants from the accessions collected from each location were examined and scoring was made according to the UPOV criteria. The morphological characteristics of the plants were observed for two years (2018 and 2019). The traits evaluated included plant height (PH), foliage attitude (FA), leaf curvature (LC), leaf waxiness (LW), green color intensity of leaf (LGC), leaf length (LL), leaf diameter (LD), time of sprouting (TS), bud shape (BSH), bud size (BS), time of beginning of flowering (TBF), flower color (FC). Four morphological characters (PH, LL, LD, and BS) were measured during vegetative period using a digital caliper. The leaf color parameters of the plants selected from each location were determined in the L, a*, b*, Chroma (C*) and Hue Angle (Hº) color plane with the Minolta CR-440 Optics Chroma meter. The time of sprouting was investigated when 10% of one-year-old plants show new sprouts at the beginning of the next year after sowing. Umbel capsule (bud) shape observations

were made when 10% of the plants have a bud and directly after bud emergence. The descriptors used and the observed classes are presented in Table 2.

2.3. Statistical analysis

Quantitative traits were examined for normal distribution by performing a Kolmogorov–Smirnov test. The data of morphological traits were divided into the groups (Sensoy et al., 2007). In the cluster analysis of the morphological data obtained in the study, the Past3 (Paleontological Statistics Version 3.20) program was used and a dendogram was performed in iTOL (Interactive tree of life) using the obtained matrix file (iTOL, 2020). Furthermore, UPGMA (Unweighted Pair Group Method with Arithmetic Mean) method was used for grouping the locations. Similarity matrices were created with Principal Coordinate Analysis (PCoA) and Euclidean coefficients were assessed to determine possible correlations between the morphological properties. All multivariate analyses were performed with IBM SPSS Statistics version 21.0. One-way analysis of variance (One-way ANOVA) was performed for data comparison, and Duncan multiple comparison test was used to determine the differences between groups (Duncan, 1955).

Table 2. UPOV descriptors and classification scores

	Descriptors	Classes	Scale	Value range
1	Plant height (PH)	Short	3	<39.93 cm
		Medium	5	39.93-52.86 cm
		Tall	7	>52.86 cm
2	Foliage attitude (FA)	Erect	1	
		Erect to semi erect	2	V
		Semi erect	3	
3	Leaf curvature (LC)	Absent or very weak	1	
		Weak	3	
		Medium	5	V
		Strong	7	
		Very strong	9	
4	Leaf waxiness (LW)	Weak	1	
		Medium	3	V
		Strong	5	
5	Green color intensity of leaf (LGC)	Very light	1	<7.34
		Light	2	7.34-8.58
		medium	3	8.58-9.82
		Dark	4	9.82-11.06
		Very dark	5	>11.06
6	Leaf length (LL)	Short	3	<21.17 cm
		Medium	5	21.17-26.24 cm
		Long	7	>26.24 cm
7	Leaf diameter (LD)	Small	3	<2.15 mm
		Medium	5	2.15-2.85 mm
		Large	7	>2.85 mm
8	Time of sprouting (TS)	Early	3	
		Medium	5	V
		Late	7	
9	Bud (Umbel capsule) shape (BSH)	Elliptic	1	
		Round	2	V
		Broad ovate	3	
10	Bud (Umbel capsule) size (BS)	Small	1	<6.5 mm
		Medium	3	6.5-8.87 mm
		Large	5	>8.87 mm
11	Time of beginning of flowering (TBF)	Early	1	
		Medium	3	V
		Large	5	
12	Flower color (FC)	Light pink	1	
		Pink	2	V
		Violet	3	

V: Visual assessment by a single observation of a group of plants or parts of plants.

3. Results

Plant Height (PH) of a total of 100 plants, 10 from each location, were measured. The PH of the selected plants varied from 27.0 cm to 65.8 cm, and the difference between the locations was statistically significant at the $p<0.01$ level. The highest PH mean (55.32±5.47 cm) was determined in the L-8 location, and the lowest value (31.38±5.47 cm) was determined in the plants belonging to the L-4 location (Table 3). PH were grouped according to UPOV criteria, while values below 39.93 cm were scored as short; values between 39.93-52.86 cm were scored as medium; Values above 52.86 cm were scored as large. According to the UPOV scoring method, 65% of plants were recorded as medium (Table 5). In terms of foliage attitude (FA), 36% of the plants were erect, 46% of them were erect to semi erect and 18% of them were semi-erect. Moreover, it has been determined that 60% of the plants were in the weak leaf curvature class. In addition, it was observed that the plants in all locations were in the medium waxiness (100%) group (Table 3).

Leaf length (LL) of the plants varied from 16.1 cm to 31.3 cm. The difference between locations was statistically significant at the $p<0.01$ level. Plants were divided into the groups having short, medium and long leaves specified in the UPOV criteria in terms of LL (Table 2). Values below than 21.17 cm were as short; values between 21.17-26.24 cm were as medium; values above than 26.24 cm were scored as long. According to this classification, 43% of the plants had short leaves; 50% of them had medium-length leaves and 7% of them had long-leaves (Table 3).

The difference between the locations in terms of leaf diameter (LD) of the plants was found to be significant at the $p<0.01$ level (Table 3). The LD of the selected 100 plants varied from 1.45 to 3.54 mm. In terms of LD, 50% of the plants had thin-leaves (Table 4).

The variation seen in bud shape (BSH) between locations was due to the fact that *A. vineale* can have bulbils and flower buds. *A. vineale* produces bulbil and this bring about shape difference in buds. Buds of accessions from some locations did not contain regular flower buds. These accessions produced only bulbils in buds. Flower buds appeared in broad ovate shape. Bulbil buds were in elliptic form.

In terms of bud size (BS), the difference between locations was found to be significant ($p<0.01$). The BS of a total of 100 plants selected from all locations varied from 4.13 mm to 11.24 mm. Thirty-eight percent of the plants had small BS; 46% of them had medium BS; 16% of them had large BS.

Flower color (FC) of the plants in the locations show variation. It has been observed that while some of the plants flowering, some plants produce only bulbils, while some umbels with flowers and bulbils. It was noted that the flower colors of the flowering plants in all locations were light pink.

When the color parameters of the leaves (L, a*, b*, C*, H^o) were evaluated, the difference between all locations was found to be statistically significant ($p<0.01$) (Table 4). The brightness value (L*) was the highest (46.25±1.03) in the plants belonging to L-1 location, and the lowest value (36.82±1.51) was measured in the plants belonging to L-2 location. The a* value, which expresses the green color intensity, was observed at the highest (-11.47±0.85) at L3 location, while the lowest value (-7.27±1.11) was observed in the plants belonging to the L-5 location. It was determined that the highest value (15.93±0.30) of the b* parameter, which shows the intensity of yellow-blue color, was in the plants belonging to the L-3 location and the lowest value (9.94±0.08) was found in the plants belonging to the L-5 location. The Chroma (C*) value, which expresses the saturation, was measured the highest (19.51±0.31) in the plants belonging to the L-7 location, and the lowest (11.47±0.93) in the plants belonging to the L-4 location. Hue value (h^o) was the highest (131.29±0.86) in L-10 location, and the lowest value (124.64±1.11) was found in plants belonging to L-4 location (Table 4). While the plants were grouped in terms of green color intensity, a* values were taken into consideration. According to this classification, 3.3% of the green color intensity of the plants were very light; 16.7% of them were light; 46.7% of them were medium; 23.3% of them were dark and 10% of them were very dark (Table 5).

Table 3. Means of some morphological characteristics of *A. vineale* accessions collected from different locations

Accession	Plant height (PH) (cm)	Leaf length (LL) (cm)	Leaf diameter (LD) (mm)	Bud size (BS) (mm)
L-1	46.47±5.53 bcd	20.65±2.70 b	2.47±0.18 bc	6.75±0.77 bc
L-2	45.16±5.64 cd	**24.98±3.60 a**	1.91±0.28 ef	6.86±1.04 bc
L-3	48.25±7.50 bc	21.48±2.86 b	2.00±0.29 de	**4.72±0.39 d**
L-4	**31.38±1.87 e**	21.52±1.31 b	**1.67±0.11 f**	5.33±0.29 d
L-5	46.32±2.73 bcd	22.92±3.06 ab	2.11±0.42 de	**9.15±1.08 a**
L-6	51.34±6.61 ab	20.75±2.32 b	2.50±0.43 abc	7.45±0.95 b
L-7	41.34±4.47 d	**20.39±1.51 b**	1.72±0.14 f	6.12±1.41 c
L-8	**55.32±5.47 a**	22.86±2.25 ab	2.28±0.28 cd	9.04±0.38 a
L-9	50.33±2.10 abc	21.25±1.74 b	2.73±0.39 ab	7.38±0.14 b
L-10	49.30±8.41 bc	21.02±2.06 b	**2.76±0.21 a**	7.57±1.31 b
Avg.	46.52±8.12**	21.78±2.69**	2.21±0.47**	7.04±1.60**

**: The difference between groups shown with different letters in the same column is significant ($p<0.01$).

Table 4. Leaf color parameter of *A. vineale* accessions collected from different locations

Accession	L	a (-)	b	C*	H°
L-1	**46.25±1.03 a**	9.57±0.03 bcd	11.61±1.06 bc	15.01±0.16 bc	128.97±0.54 b
L-2	**36.82±1.51 d**	9.47±0.03 bcd	11.40±0.97 bc	15.47±0.15 b	130.37±0.33 a
L-3	42.54±2.59 bc	**11.47±0.85 a**	**15.93±0.30 a**	19.50±0.03 a	126.17±1.03 c
L-4	40.97±2.08 c	10.50±0.64 ab	11.49±0.21 bc	**11.47±0.93 f**	**124.64±1.11 d**
L-5	46.20±1.07 a	**7.27±1.11 e**	**9.94±0.08 d**	12.41±0.02 e	126.73±0.99 c
L-6	41.54±0.89 c	9.80±0.26 bc	11.57±0.51 d	14.63±0.31 c	130.74±0.25 a
L-7	41.38±1.18 c	9.19±0.17 cd	11.63±0.34 bc	**19.51±0.31 a**	128.51±0.14 a
L-8	44.31±1.17 ab	8.45±1.04 d	10.52±0.26 d	13.51±0.07 d	128.30±0.17 b
L-9	41.20±1.09 c	9.30±0.33 bcd	12.29±0.18 b	15.46±0.10 b	126.43±0.71 b
L-10	40.62±0.50 c	9.63±0.43 bcd	11.13±0.92 c	13.16±0.71 d	**131.29±0.86 a**
Avg.	42.18±2.98**	9.46±1.21**	11.75±1.62**	15.01±2.63**	128.22±2.20**

**: The difference between groups shown with different letters in the same column is significant ($p<0.01$).

Table 5. Proportional distribution of *A. vineale* accessions according to UPOV descriptors (%)

No	Descriptor	Distribution frequency of plants by descriptors (%)				
01	PH	Short (14)	Medium (65)	Tall (21)		
02	FA	Erect (36)	Erect to semi erect (46)	Semi erect (18)		
03	LC	Absent or weak (20)	Weak 60)	Medium (20)	Strong (0)	Very strong (0)
04	LW	Weak (0)	Medium (100)	Strong (0)		
05	LGC	Very light (3.3)	Light (16.7)	Medium (46.7)	Dark (23.3)	Very Dark (10)
06	LL	Short (43)	Medium (50)	Long (7)		
07	LD	Small (36)	Medium 00 (34)	Large (30)		
08	TS	Early (30)	Medium (30)	Late (40)		
09	BSH	Elliptic (40)	Round (0)	Broad ovate (60)		
010	BS	Small (38)	Medium (46)	Large (16)		
011	TBF	Early (30)	Medium (20)	Late (50)		
012	FC	Light pink (100)	Pink (0)	Violet (0)		

The cluster analysis was performed to observe the differences in terms of morphological descriptors of plants collected from different locations; and all locations were divided into two main groups (Figure 2). When the similarity matrices of the locations in Table 6 were examined, four locations the farthest from each other in terms of morphological traits were L1-L7 and L7-L9 (10.724), L4-L5 (9.695) and L1-L4 (9.105). However, the most similar locations in terms of all traits were L1-L9 (0.000), L5-L6 (3.606), L4-L10 (4.472) locations. The similarities and distances of the locations from each other were also clearly seen in the basic coordinate analysis (Figure 3). The plants from four locations (L-3, L-4, L-7 and L-10) in different groups were collected from a relatively higher altitude (2075, 2290, 2245 and 2390 m) compared to other locations (Figure 3 and Table 1).

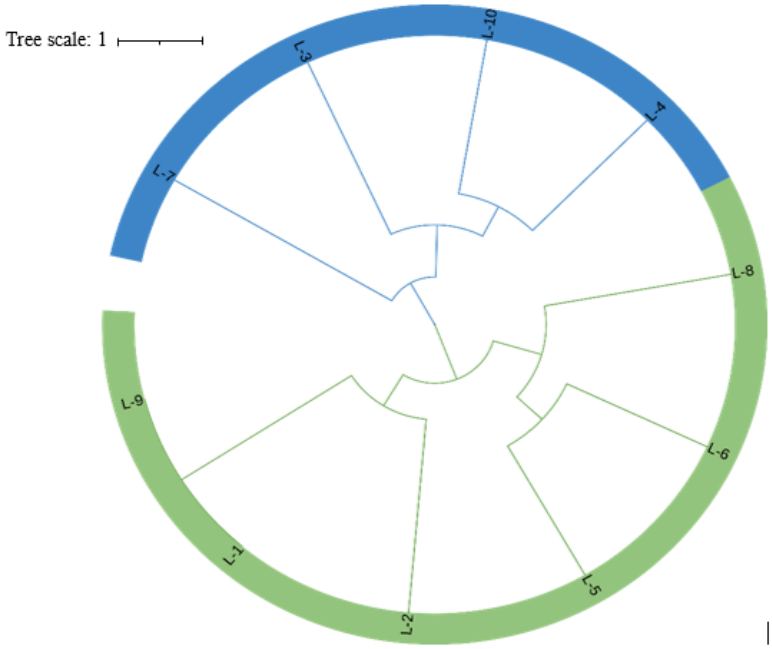

Figure 2. UPGMA-based clustering generated from the morphological data set.

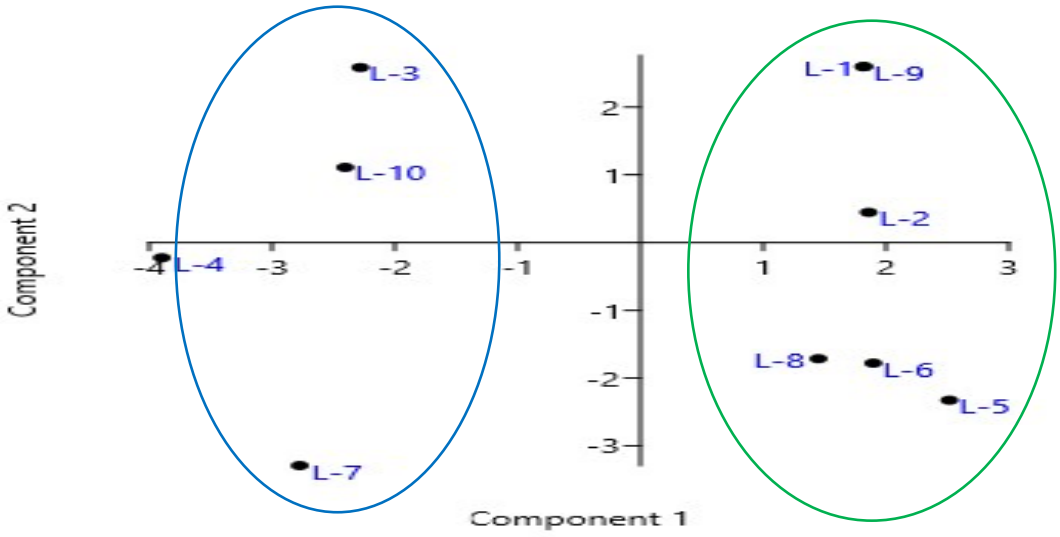

Figure 3. Principal Coordinate Analysis of *A. vineale* accessions collected from different locations.

Table 6. Similarity matrix of *A. vineale* accessions collected from different locations by using Euclidean coefficients

	L-1	**L-2**	**L-3**	**L-4**	**L-5**	**L-6**	**L-7**	**L-10**	**L-11**	**L-12**
L-1										
L-2	5.385									
L-3	6.782	7.141								
L-4	9.165	9.000	6.164							
L-5	7.211	5.385	9.592	9.695						
L-6	7,000	5.477	9.220	9.327	3.606					
L-7	10.724	8.944	8.426	5.745	7.681	7.348				
L-8	6.782	6.856	9.487	8.000	4.690	5.568	7.810			
L-9	0,000	5.385	6.782	9.165	7.211	7.000	10.724	6.782		
L-10	6.928	7.810	4.690	4.472	8.718	8.062	7.141	7.874	6.928	
Ort.	**5.998**	**6.138**	**6.829**	**7.073**	**6.379**	**6.261**	**7.454**	**6.385**	**5.998**	**6.262**

4. Discussion and Conclusion

Studies on the plant morphology of *A. vineale* are very limited. For this reason, morphological findings were compared with studies on other wild garlic species. When the findings were examined, it was determined that two morphological traits [leaf waxiness (Weak) and flower color (Light pink)] showed monomorphism. In addition, 10 morphological traits were observed to differ between locations. Morphological differences in leaf shape and size are important for the ornamental plant potential of plants (Stummel and Bosland, 2007). Leaf curvature may increase temporarily during flowering in most *Allium* species. However, in some species (*A. cernuum*), the leaves are permanently curved (Choi and Cota-Sa´nchez, 2010). As a result of our observations, it was seen that *A. vineale* plants had semi-erect and weakly curved plant form. Morphological leaf characteristics can show polymorphism greatly among *Allium* species and therefore can be used as a descriptive criterion among *Allium* species (Aryakia et al., 2016). It has been determined by some studies that wild *Allium* species show morphological differences in terms of plant length, leaf length and leaf diameter compared to the cultivated species (Nomura and Makara., 1996; Friesen et al., 2000; Aryakia et al., 2016).

It was observed that the degree of leaf waxiness of the accessions in the study was medium. Leaf waxiness is a morphological feature that protects the weak leaves of plants against biotic (fungi, bacteria, etc.) and abiotic (temperature, etc.) stresses (Subudhi and Raut, 1994; Mondal et al., 2015). The waxiness is important for the use of *Allium* species (Liu et al., 2014) and other species (Subudhi and Raut, 1994; Mondal et al., 2015) in genetic breeding programs and evolutionary studies. In terms of green color intensity, the majority of plants (46.7%) were in the medium color intensity class. Color intensities of the accessions from different locations vary frequently. The variation in the color intensity of plants has also been supported by previous studies on different plant species (De Souza et al., 2012; Joshi et al., 2013; Taşcı et al., 2019). When the results were compared with the literature (a* value), it was found that the leaves of *A. vineale*, and *A. scorodoprasum* L. subsp. *rotundum* (L.) STEARN leaves appear to have a darker green color intensity. In addition, the higher L* brightness value supports the medium waxiness of *A. vineale* in its classification according to UPOV criteria. Variation in color intensity among *Allium* species might be an important for selection as a morphological marker in all breeding programs (Aryakia et al., 2016). The flowering times in the ecological conditions in the area where the study was carried out were grouped as early, med and late-flowering ones. Flowering times of most of the accessions are classified in the late group. Flowering times of all locations were found to be close to each other. Fritsch and Abbasi (2013) reported that flowering times in plants may differ in nature. The fact that the flowers open at different times can be considered as a long-term flowering period and this feature also shows that *A. vineale* can be evaluated as an ornamental plant.

According to the UPOV traits, cluster analysis accessions were divided into two groups. It has been seen in previous studies that morphological differences between and within species are differentiated in cluster analysis (Pooler and Simon 1993; Friesen et al., 2000; Panthee et al., 2006). The fact that the plants examined in the study were the same as species was supported by the species identification. However, it is thought that the difference between the locations is due to the effect of

factors such as geographical location, ecology, and harvest time. In addition, Aryakia et al. (2016) stated that there may be morphological differences in subspecies of *Allium* species.

This is the first study utilizing UPOV descriptors in evaluation of wild *A. vineale* germplasm in Turkey. The morphological characterization of wild germplasm from different locations in Van province revealed phenotypic diversity. It has been seen that the accessions in the locations were divided into two main groups based on the morphological traits. According to the morphological measurement data obtained, it was found that *A. vineale* has a thinner leaves and shorter plant height when compared to other edible *Allium* species (Nomura and Makara, 1996; Panthee et al., 2006; Ebrahimi et al., 2009). Moreover, it is thought that the difference in flower density of plants may be affected by genetic characteristics or environmental conditions. It was observed that accessions from some locations formed high numbers of bulbils. This indicates that *A. vineale* reproduces asexually by bulbils as well as seeds. Finally, observations and measurements for morphological classification provides the opportunity to detect valuable germplasm materials suitable for use in future breeding programs.

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