Determination of *Salvia* species and soil property naturally distributed in Kırşehir provinces

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Abstract: Turkey has a rich plant flora due to the reasons such as excessive micro-climate fields occurring due to topographic characteristics and different climates. So, Turkey includes 12 thousand plant taxa. Kırşehir city is rich in plant variety due to the metamorphic massives it includes. In this study, as a result of the surveys performed in 2017, 2018 and 2019 vegetation periods in Kırşehir city, it was determined that *Salvia aethiopis* L.*, Salvia absconditiflora* Greuter & Burdet, *Salvia syriaca* L., *Salvia ceratophylla* L., *Salvia bracteata* Banks et Sol., *Salvia cyanescens* Boiss. & Bal., *Salvia sclarea* L. and *Salvia virgata* Jacq. species spread naturally. According to the study, it was determined that *Salvia absconditiflora* species was common in Kırşehir and formed population in the fields where it was present. *Salvia virgata* and *Salvia sclarea* species spread mostly on the roadsides, whereas, the other species spread in empty grasslands such as pasture. The soil requirements of the plants were determined by the soil samples obtained from the locations where the plants were collected. It was revealed that the determined *Salvia* species varied much in terms of soil requirements, elevation and habitat. The soils had a clay and loamy structure and following values were determined; pH values of 7.69-8.30, salinity value of 0.003-0.02%, organic matter content of 1.509-4.618%, calcium carbonate content of 3.776-67.454%, available K value of 55.206-160.023 kg K_2O/da, and available P value of 1.543-24.197 kg P_2O_5/da. Kırşehir is rich in *Salvia* species and *Salvia* species are tolerant against slightly alkaline, clay, loamy and calcareous soils having low amount of organic matters.

Keywords: Sage, biodiversity, ecology, habitat, soil properties, Turkey

Kırşehir İl'inde Doğal Yayılış Gösteren Adaçayı Türleri ve Toprak Özelliklerinin Belirlenmesi

Öz: Ülkemiz topografik özellikler ve sahip olduğu faklı iklim sayesinde oluşan mikroklima alanların fazlalığı gibi nedenlerden dolayı zengin bitki florasına sahiptir. Bu sayede ülkemiz 12 bin bitki taksonuna ev sahipliği yapmaktadır. Kırşehir İli sahip olduğu metamorfik masiflerden dolayı bitki çeşitliliği bakımından zengindir. Bu çalışma ile Kırşehir İl'inde 2017, 2018 ve 2019 vejetasyon dönemlerinde gerçekleştirilen surveyler sonucu *Salvia aethiopis* L.*, Salvia absconditiflora* Greuter & Burdet, *Salvia syriaca* L., *Salvia ceratophylla* L., *Salvia bracteata* Banks et Sol., *Salvia cyanescens* Boiss. & Bal., *Salvia sclarea* L. ve *Salvia virgata* Jacq. türlerinin doğal olarak yayılış gösterdiği belirlenmiştir. Çalışmaya göre *Salvia absconditiflora* türünün Kırşehir'de yaygın olduğu ve bulunduğu alanlarda popülasyon oluşturduğu tespit edilmiştir. *S. virgata* ve *S. sclarea* türlerinin daha çok yol kenarlarında; diğer türlerin ise mera gibi boş otlak alanlarda yayılış gösterdiği belirlenmiştir. Bitkilerin toprak gereksinimleri, bitkilerin toplandığı yerlerden elde edilen toprak örnekleri ile belirlenmiştir. *Salvia* türlerinin toprak gereksinimleri, rakım ve yaşam alanları açısından çok değişkenlik gösterdiği belirlenmiştir. Topraklar killi ve tınlı bir yapıya sahip olup pH değerleri 7.69-830, tuzluluk değeri %0.003-0.02, organik madde içeriği %1.509-4.618, kalsiyum karbonat içeriği %3.776-67.454, mevcut K değeri 55.206-160.023 kg K_2O/da ve mevcut P değeri 1.543-24.197 kg P_2O_5/da olarak saptanmıştır. Kırşehir, *Salvia* türleri bakımından zengindir ve *Salvia* türleri organik madde miktarı az olan hafif alkali, killi, tınlı ve kireçli topraklara karşı toleranslıdır.

Anahtar Kelimeler: Adaçayı, biyoçeşitlilik, ekoloji, habitat, toprak özellikleri, Türkiye

1. Introduction

Turkey provides opportunity for the development of the plant species with many different characteristics due to its different climatic and geological structure. The fact that Turkey is situated in a location where three different floristic regions including Iran-Turan, Mediterranean, Europe-Siberia unite and perform transition is also a reason of this richness (Eyuboglu, 2019). In Turkey, more than 12.000 plant taxa spread naturally and approximately 1/3 of them are endemic taxa (Senkul and Kaya, 2017). Lamiaceae is the 3rd largest family in Turkey and it has a great area in the world with 236 genera and 7133 species (Harley et al., 2004) and spreads in tropical and temperate regions and especially high plains with seasonal climate (Cantino et al., 1992). Turkey is one of the important gene centers of Lamiaceae family and its 45 genera, 558 species and 742 taxa are present in Turkey and its endemism rate is 42.2% (Koyuncu et al., 2010; Belen, 2012).

Salvia genus included in Lamiaceae family is represented with 96 species and 4 subspecies in Turkey and its endemism rate is 51% (Demirci et al., 2003; Poyraz and Koca, 2006). Salvia species are among the important aromatic plants with their volatile oil richness and they have a wide area of usage (Yilar and Kadioglu, 2018).

Central Anatolia Region is considered as the habitats for Salvia species which are almost determined with a line. For example, *Salvia recognizeita* follows a line from Kayseri to Ankara, from Mount Elma and Kalecik and Mount Eldivan Region to Çubuk Dam in the northwestern Ankara (Bagherpour, 2010). Kırşehir province is in the Middle Kızılırmak Region of Central Anatolian Region. As the region where it is located is arid and tectonic, the soil characteristics differ based on climate and parent material (Abaci Bayan, 2018). In addition, due to its metamorphic massives, it is considered to be rich in plant diversity and endemism. The aim of this study is to reveal the *Salvia* species spreading naturally in Kırşehir province and their variations based on the soil characteristics and locations.

2. Material and Method
2.1. Field of study

The field of study is Kırşehir city located in Central Anatolian Region and it has a surface area of 6665 km^2 and its altitude is 985 m. Kırşehir province is located between 38°50′-39°50′ northern latitudes and 33°30′-34°50′ eastern longitudes.

2.2. Survey Studies

In order to determine the *Salvia* species naturally spreading in Kırşehir, surveys were performed in 2017, 2018 and 2019 vegetation periods. In the surveys, the coordinates of the locations of Salvia species and their soil samples were obtained and herbarium of each plant was performed. The plants were identified by us and Expert İlker Türkay (Kırşehir Ahi Evran University).

2.3. Obtaining soil samples and their analyses

Disturbed soil samples were obtained from 0-20 depth in the research areas. "Water saturation percentage, Determination of texture, Soil reaction, Electrical conductivity, Total lime, Organic matter, Determination of available phosphorus, and alterable K" analyses of the soil samples were performed using standard techniques (Abaci Bayan 2016) and the results were assessed according to Ulgen and Yurtsever (1995). The data obtained from the survey studies were assessed with conical compatibility analysis (CCA) using CANOCO packaged software and the graphics were obtained. So, the soil property factors were associated with Salvia species and it was revealed which soil property was effective on Salvia species.

3. Results and Discussion

Kırşehir is rich in plant variety and endemism due to its metamorphic massives and also its soil, climatic and similar properties differ as it is arid and tectonic. But, there are a limited number of flora and vegetation studies on Kırşehir flora. According to these studies, 390 genera and 779 species (803 species and

subspecies taxa) belonging to 85 families have been determined in Kırşehir.

As a result of the surveys performed during 2017, 2018 and 2019 vegetation periods, it was determined that *Salvia aethiopis* L.*, Salvia absconditiflora* Greuter & Burdet, *Salvia syriaca* L., *Salvia ceratophylla* L., *Salvia bracteata* Banks et Sol., *Salvia cyanescens* Boiss. & Bal., *Salvia sclarea* L. and *Salvia virgata* Jacq. species spread naturally in Kırşehir city (Figure 1). Table 1 shows the information on the locations where the species spread.

Figure 1. *Salvia ceratophylla* (a), *S. absconditiflora* (b), *S. syriaca* (c), *S. sclarea* (d), *S. aethiopis* (e), *S. bracteata* (f), *S.virgata* (g), *S. cyanescens* (h)
Şekil 1. *Salvia ceratophylla (a), S. absconditiflora (b), S. syriaca (c), S. sclarea (d), S. aethiopis (e), S. bracteata (f), S.virgata (g), S. cyanescens (h)*

The results of the study revealed that 8 Salvia species determined in Kırşehir city which has a rich bio-diversity due to its metamorphic massives spread in many different soil properties, habitats and altitudes. *Salvia absconditiflora*, one of these species, was determined in a great majority of the locations where the surveys were performed, and it spread in almost every region of the city. *Salvia absconditiflora* species*, which spread mostly,* was followed by *Salvia syriaca, Salvia aethiopis*, *Salvia ceratophylla* and others. Extremely specialized *Salvia* species such as *Salvia cyanescens* growing at high altitudes (over 1300 meter) were found (Table 1).

In the limited number of studies conducted on Kırşehir flora, the plant taxa spreading in the region were determined. But these studies have been conducted being specialized in certain fields. Keles (1998) determined 466 taxa of 53 families in Mount Naldöken flora. It was also revealed that 66 families, 324 genera, and 624 species spread in west side flora of Çiçekdağ (Polat, 1998).

In similar studies conducted in the study region, the presence of *Salvia cyanescens* Boiss.&Ball., *S. blepharochlaena* Hedge&Hub.-Mor., *S. absconditiflora* Montbret&Aucher ex Bentham, *S. viridis* L., *S. hypargeia* Fisch.& Mey., *S. aethiopsis* L., *S. frigida* Boiss., *S. virgata* Jacq., *S. verticillata* L. subsp. amasiaca (Freyn & Bornm.) Bornm., *S. russellii* Benth., *S. modesta* Boiss. species has been reported (Vural et al., 1997; Bagherpour, 2010). Also, the existence of *Salvia hypargeia* species has been reported in Kırşehir (Aktoklu and Arslan, 2012). It was revealed in this study that *Salvia ceratophylla*, *Salvia bracteata* and *Salvia sclarea* species, which were not included in the results of the limited number of studies, spread naturally in Kırşehir city.

Table 1. Spreading locations of *Salvia* species in Kırşehir province
Çizelge 1. Kırşehir ilinde Salvia türlerinin yayılış gösterdiği lokasyonlar

Sample number	Species of sage detected	Received Point	Coordinates North	East	Altitude (m)
1	*S.absconditiflora* *S. syriaca* *S.virgata*	Mucur output	39⁰ 03′ 03.73″	34⁰29′29.09″	1143
2	*Salvia syriaca*	Center	39⁰ 5′ 32.22″	34⁰10′25.1″	1020
3	*S. ceratophylla* *S. absconditiflora* *S. sclarea*	Mucur entry	39⁰ 03′ 50.14″	34⁰20′14.84″	1115
4	*S. syriaca* *S. aethiopis*	Akçakent	39⁰ 36′ 57.54″	34⁰5′32.42″	1307
5	*S. absconditiflora* *S. syriaca* *S. cyanescens*	Çiçekdağ	39⁰ 29′ 8.27″	34⁰19′49.3″	1108
6	*S. cyanescens*	Çiçekdağ entry	39⁰ 35′ 25.4″	34⁰14′42.4″	1343
7	*S. absconditiflora* *S. bracteata*	Akçakent/Hamzabey village	39⁰ 36′ 32.01″	34⁰4′37.95″	1263
8	*S. aethiopis* *S. syriaca*	Akpınar	39⁰ 28′ 28.04″	33⁰59′10.71″	1030
9	*S. absconditiflora* *S.aethiopis*	Çiçekdağ	39⁰ 34′ 3.24″	34⁰23′7.16″	1237
10	*S. syriaca*	Akpınar	39⁰ 20′ 8.97″	34⁰1′24.95″	1138
11	*S. absconditiflora* *S. ceratophylla*	Akçakent entry	39⁰ 32′ 17.5″	34⁰0′8.77″	1021
12	*S. aethiopis*	Center	39⁰ 6′ 30.74″	34⁰12′10.93″	1065
13	*S. cyanescens*	Akçakent	39⁰ 34′ 41.38″	34⁰10′3.11″	1323
14	*S. aethiopis*	Göllü village	39⁰ 26′ 56.47″	34⁰17′54.11″	1223
15	*S. absconditiflora* *S. syriaca*	Akpınar	39⁰ 27′ 3.02″	33⁰58′32.63″	1059
16	*S. syriaca* *S. aethiopis* *S. ceratophylla*	İsahocalı	39⁰ 26′ 6.47″	34⁰17′54.11″	1227
17	*S. absconditiflora*	Kaman-Sarıyahşi	39⁰ 18′ 5.97″	33⁰43′2.22″	1249
18	*S. syriaca* *S. aethiopis* *S. ceratophylla* *S. bracteata*	Kaman entry	39⁰ 22′ 8.15″	33⁰48′43.64″	1041
19	*S. absconditiflora*	Kaman output	39⁰ 18′ 5.97″	33⁰43′2.22″	1249
20	*S. absconditiflora*	Center/Campus	39⁰ 08′ 7.50″	34⁰07′01.15″	1088

In this study, the environmental factors of *Salvia* species such as soil, altitude and habitat were analyzed. Soil is one of the most important ecological factors. Many researchers have determined that Salvia is especially affected by soil type (Davis, 1951; Akpulat and Celik, 2005). According to the analyses of the soil samples obtained from the habitats appropriate for *Salvia* taxa (Table 2), they generally preferred the slightly alkaline (7.85 on average) and clay, loamy soil with low organic matter (2.17% on average). When the total salinity content of the soil samples was examined, it was found that it varied between 0.003% and 0.02% and it was 0.015% on average. It was observed according to the

classification made by Ulgen and Yurtsever (1995) that the soil of the area was salt-free. It was determined that the total calcium carbonate content varied between 3.776% and 67.454% and it was 26.37% on average. Based on the classification, the soil of the area was included in the very calcareous class. It was determined that the most tolerant species in terms of calcium carbonate were *Salvia absconditiflora, Salvia syriaca* and *Salvia cyanescens* (Table 2). The available K value of the soil of the area varied between 55.206 kg K2O/da and 160.023 kg K2O/da and was 88.472 kg K2O/da on average. Based on the classification performed, it was observed that there was enough potassium in the soil. It was determined in the examination

of the available P content of the soil samples that it varied between 1.543 kg P2O5/da and 24.197 kg P2O5/da, it was averagely 4.223 kg P2O5/da and it contained low level of phosphorus. The fact that pH of the soil samples was over 7 and there was high amount of CaCO3 in the environment may be explained by the high Ca-P in the inorganic phosphorus fraction of the soil of the area and, then, the high level of Al-P, Fe-P fraction. In the calcareous, alkaline soil with of pH>7.5, phosphorus is fixed by converting tricalcium phosphate, which has very low dissolubility. Also, the fact that of pH>7.5 and the organic matter is at the low level decreases the usage of phosphorus by plants.

Table 2. Soil characteristics of the locations where *Salvia* species spread in Kırşehir.
Çizelge 2. Kırşehir'de Salvia türlerinin yayılış gösterdiği lokasyonların toprak özellikleri

Sample number	Species of sage detected	Water saturation percentage (%)	Texture*	pH	Total salinity (%)	CaCO₃ (%)	Organic matter (%)	K₂O (kg da⁻¹)	P₂O₅ (kg da⁻¹)
1	*S. cryptantha* *S. syriaca* *S.virgata*	62.7	CL	8.22	0.015	22.313	1.6	160.023	4.573
2	*S. syriaca*	58.85	CL	8.15	0.013	27.462	1.901	118.278	6.812
3	*S. ceratophylla* *S. cryptantha* *S. sclarea*	50.6	L	8.04	0.012	49.089	1.569	72.146	6.68
4	*S. syriaca* *S. aethiopis*	55	CL	7.92	0.008	9.955	3.411	91.96	9.841
5	*S. cryptantha* *S. syriaca* *S. cyanescens*	72.6	L	8.25	0.015	67.454	1.871	113.589	3.256
6	*S. cyanescens*	42.9	L	7.98	0.003	6.522	2.173	121.756	12.08
7	*S. cryptantha* *S. bracteata*	58.3	CL	8.09	0.008	14.074	3.501	98.766	3.914
8	*S. aethiopis*	64.9	CL	8.2	0.018	20.253	1.6	144.595	3.124
9	*S. cryptantha* *S. aethiopis*	67.1	CL	8.28	0.014	31.238	2.656	125.84	4.046
10	*S. syriaca*	58.85	CL	8.2	0.010	25.059	2.445	138.999	7.075
11	*S. cryptantha* *S. ceratophylla*	61.6	CL	8.3	0.010	27.806	1.509	73.205	1.807
12	*S. aethiopis*	55	CL	8.17	0.008	20.94	2.324	119.639	3.914
13	*S. cyanescens*	62.7	CL	8.21	0.009	10.642	3.139	100.279	4.178
14	*S. aethiopis*	64.35	CL	8.16	0.008	48.746	4.618	156.846	24.197
15	*S. cryptantha* *S. syriaca*	59.95	CL	7.91	0.011	3.776	2.777	91.053	1.543
16	*S..syriaca* *S. aethiopis* *S. ceratophylla*	71.5	C	8.02	0.012	30.865	3.954	139.755	4.178
17	*S. cryptantha*	42.9	L	8.16	0.007	7.037	1.388	88.028	2.07
18	*S. syriaca* *S. aethiopis* *S. ceratophylla* *S. bracteata*	61.6	CL	8.21	0.011	44.97	2.022	86.213	4.968
19	*S. cryptantha*	52.8	CL	7.69	0.009	3.776	3.712	55.206	11.553
20	*S. cryptantha*	55.00	CL	7.59	0.02	27.90	1.81	66.62	2.14

*C: Clay, L: Loamy, CL: clay-loam

The data obtained from the soil properties and *Salvia* species surveys were assessed by conical compatibility analysis (CCA) and its effect on *Salvia* species was revealed. In the examination of the biplot (Figure 2) found as a result of the CCA, it was observed that *Salvia* species were separated into 4 different groups. Among these groups, 1st group was affected by EC, K2O, P2O5, 2nd group was affected by total lime, 3rd group was affected by water saturation percentage and pH and the 4th group was affected by organic matter. In the examination of the Figure 2, *Salvia aethiopis*, *Salvia syriaca* and *Salvia virgata* species spread in the soil with similar properties in terms of the total salinity of soil, alterable potassium and

available phosphorus content. It was observed that the soil types on which these species planted in were salt-free and had enough potassium and a wide range of phosphorus content (Table 2). *Salvia sclarea* differed from the other species with the lime content of soil. Because these species have been adapted to the soil containing high level of lime. *Salvia cyanescens* differed from other species in terms of the saturation value and pH of soil. It was determined that *Salvia ceratophylla*, *Salvia absconditiflora, and Salvia bracteata* species had the same properties in terms of the organic matter content of soil.
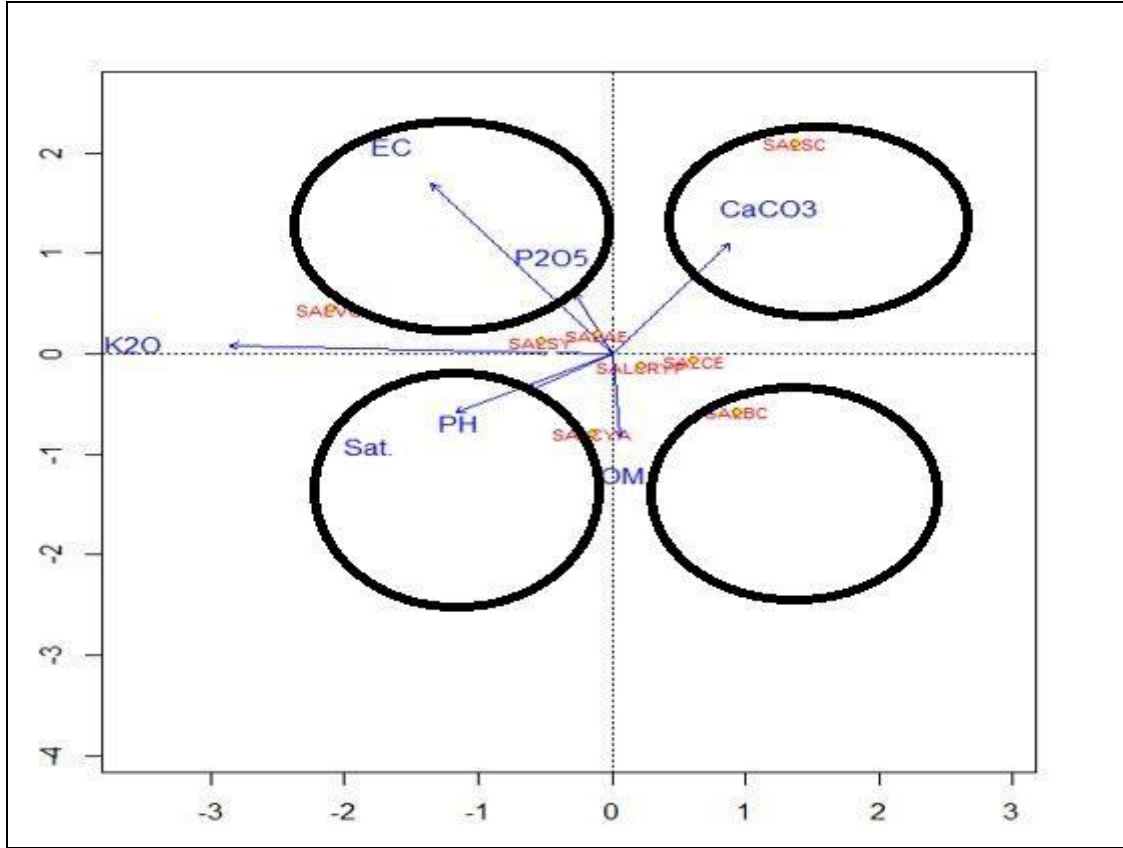

Figure 2. Distribution of Salvia species based on the soil properties
Şekil 2. Toprak özelliklerine bağlı olarak Salvia türlerinin dağılımı

It has been reported in many studies in the literature that ecological conditions are effective on the distributions of plants (Anderson and Milberg, 1998; Yirefu and Tana 2007; Sengonul et al., 2009). As in the other plant species, *Salvia* species may also differ based on the plant structure, geographic and topographic location, and some physical and chemical characteristics of soil. It has been stated in the study by Bagherpour (2010) that while *Salvia* taxa are limited with approximately 400-3200 m altitude above sea level, most of the *Salvia* species in Central Anatolian Region are generally located at an altitude of 1000 meter. *Salvia* species spread at the altitudes varying between 1200-2500 meters and they prefer the slopes between 15% - 45%. Also, *Salvia* species grow in the deep or semi-calcareous soil of the mountains with high altitudes, eroded at a medium-high level. It was reported that the main factors affecting the distribution of *Salvia* species in the east regions of Spain are climate, altitude, soil type, soil texture, organic matter and calcium content of soil (Armaki et al., 2015). Boira and Blanquer (1998) reported that some factors such as altitude, soil structure and climate were effective on the development of *Salvia piperella* L.

Generally, *Salvia* species prefer calcareous bedrock. *Salvia* taxa generally prefer clay and slightly alkaline (pH 7.83 on average) soil types with low organic matter content (1.99% on average). It was determined that the nitrogen (N) and lime (CaCO3) contents of the soil were 0.13% and 20.71%, respectively; available P and available K amounts were 4.82 and 151.52 mg kg-1 and it was also observed in the same study that the salinity of soil varied from 0.01 to 0.07% and similar results were obtained (Bagherpour, 2010). Ekim et al (2000) stated that endemic *Salvia* species became intense in calcareous areas and arid soil around the Salt Lake. Ekren et al (2007) determined the properties of the soil in which *S. officinalis* L. species grew in their study conducted in Bornova test field of Ege University Faculty of Agriculture Department of Field Crops. It has been reported that the clay loamy soil was slightly alkaline, rich in lime, poor in organic matter, poor in available phosphorus and rich in potassium and had the pH of 8.2.

results obtained from the properties of the soil in which *Salvia* species grew showed similarity.

were obtained by GPS coordinates and the properties of the soil they grew in were determined. It was observed that Salvia species grew generally at 1000 meter and higher altitudes in Kırşehir. It was determined that *Salvia absconditiflora* species was intensive in the study field, which was followed by *Salvia syriaca*, *Salvia aethiopis*, *Salvia ceratophylla*, *Salvia cyanescens*, *Salvia bracteata*, *Salvia virgata* and *Salvia sclarea* species.

4. Conclusion

According to the analysis results of the disturbed soil samples obtained from the areas where Salvia grows, it was determined that they preferred clay loamy, slightly alkaline soil with low organic matter. Available P amount preferred by very calcareous salt-free soil was low and K amount was enough. It was observed that the adaptation of *Salvia absconditiflora* species was high in the field. The relationship of Salvia species with the soil properties was

The pH of 6-7 for plants was considered to be ideal in their nutrition in terms of phosphorus, involvement of phosphorus in soil and its availability to plants were observed to be more (Kacar, 1984). Kulak (2011) used the clay, slightly alkaline (pH 8.27), too much calcareous salt-free soil with high level of organic matter and enough phosphorus and potassium in the study conducted on the different salt concentrations of *S. officinalis* L. species. The fact that the soil was calcareous limited the toxicity ability of sodium by antagonistic mechanism and it made it available for the plant. Angelova et al (2016) have investigated heavy metal resistance of *S. sclarea* species in soil. They reported that pH of 3 different soil types in which the species grew was between 7.4 and 7.5 and slightly acidic and neutral, had moderate level of organic matter, their potassium was between 5467.6 and 6960.0 mg kg-1 and phosphorus was between 387.3 and 840.0 mg kg-1. When the literature studies were examined, this study conducted with the

The geographical locations of the *Salvia* species spreading in Kırşehir city and districts in Central Anatolia Region demonstrated in graphic as a result of CCA. *Salvia aethiopis*, *Salvia syriaca* and *Salvia virgata* species spread in soil which were similar in terms of salinity, potassium and phosphorus content of the soil; whereas, *Salvia ceratophylla*, *Salvia absconditiflora,* and *Salvia bracteata* species spread in soil with similar organic matter. *Salvia sclarea* differed from the other species in terms of lime content of soil and *Salvia cyanescens* differed from the other species in terms of the saturation value and pH of soil. The distribution of Salvia species in Kırşehir city and its districts based on properties of the soil was determined in this study and it would lead all the future studies.

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