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Table: 4, Figs : 7

Allelopathic and Antifungal potentials of endemic *Salvia absconditiflora* Greuter & Burdet collected from different locations in Turkey

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ABSTRACT

We determined the antifungal and bioherbicidal properties of essential oils of *Salvia absconditiflora*. Its plant samples were collected from 10-locations in Kırşehir province, Turkey and dried in shade. Essential oils of dried plant samples were extracted by hydro-distillation method using a Schilcher device and the compounds identified in *S. absconditiflora* essential oils by GC-MS analysis were: Camphor (10.52-58.64%), Bicyclo [2.2.1] Heptane-2-One, 1.7.7 (21.94-30.16%) and viridiflorol (3.42-25.2%). *S. absconditiflora* essential oil (a dose of 10 µl/petri dishes) inhibited the mycelium growth of *Sclerotinia sclerotiorum* and *Alternaria solani* pathogens by 9.3 and 54.40 %, respectively. At dose of 20 µl/petri dish, the essential oil completely inhibited the mycelium growth of both pathogens. The *S. absconditiflora* essential oil at 20 µl/petri dish. was 100 % phytotoxic to seed germination and seedling growth of *Lepidum sativum* and *Amaranthus retroflexus.* Thus *S. absconditiflora* essential oil can be used as an alternative to synthetic fungicide and herbicide to control the plant pathogenic fungi and weeds, respectively.

Keywords: Allelopathy, *Amaranthus retroflexu,s* antifungal, chemical compounds, essential oils, fungi, fungicide, GCMS, herbicide, w *Lepidum sativum,* seed germination, seedling growth, weeds

INTRODUCTION

The Lamiaceae (Labiatae) family, has 236 genera and 7133 species, hence, distributed Worldwide in tropical and temperate regions (11,22). Turkey is one of the important gene centre of Lamiaceae family [45 genus, 558 species and 742 taxa are found and the endemism rate is 42.2% (5,31)]. *Salvia* genus (Lamiaceae family) has 96 species and subspecies in Turkey and the endemic rate is 51% (14,15). *Salvia* genera are important aromatic plants, rich in essential oils used for various purposes (54). These oils are rich in terpenoid compounds, flavonoids, phenolic compounds and quinoids (4,7,15,16,49). *Salvia absconditiflora* Greuter & Burdet (Synonim : *Salvia cryptantha* Montbret & Aucher ex Bentham) is an endemic specie in the C group (Figure 1) (15) in rocky areas, calcareous hills and high-altitudes (700-2500 m).This genus grows in Terrestrial Central Anatolia, Turkey and is medicinal plant [antitumor (35), antioxidant and wound healing (43)] and this plant has biological activity(27,52). It is perennial plant (10 to 30 cm in height) (24,35).

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This study aimed to determine the chemical composition of essential oils from *Salvia absconditiflora* plant and studied their used in biological activity against plant pathogens and weeds.

MATERIALS AND METHODS

I. Plant Samples: *Salvia absconditiflora* plant samples (shoot + steam + leaf) were collected from 10-sites during the flowering stage in 2017-2018 Kırşehir (North: 39^0 08′ 27.50″ East: $34^0$07′01.15″, altitude:1088 m), Total mean rainfall : 173.4 mm, mean temperature : 14.8 °C (Table 1). The collected plants shoot, stem and leaves were dried in shade at 25ºC and stored for the experiments.

Table 1. *Salvia absconditiflora* populations collected from Kırşehir province

Site Number	Locations	Coordinates		Altitude (m)
		North	East	
1	Çiçekdağ entry	39^0 29′ 8.27″	$34^0$19′49.3″	1108
2	Centry/Campus	39^0 08′ 27.50″	$34^0$07′01.15″	1088
3	Village Akçakent/ Hamzabey	39^0 36′ 32.01″	$34^0$4′37.95″	1263
4	Kaman exit	39^0 18′ 25.97″	$33^0$43′2.22″	1249
5	Mucur exit	39^0 03′ 03.73″	$34^0$29′29.09″	1143
6	Akçakent entry	39^0 32′ 17.5″	$34^0$0′8.77″	1021
7	Akpınar	39^0 27′ 13.02″	$33^0$58′32.63″	1059
8	Çiçekdağ exit	39^0 34′ 3.24″	$34^0$23′7.16″	1237
9	Kaman-Sarıyahşi	39^0 06′ 24.12″	$33^0$54′56.01″	906
10	Mucur entry	39^0 03′ 50.14″	$34^0$20′14.84″	1115

Figure 1. *Salvia absconditiflora* plant Greuter & Burdet

II. Extraction of essential oils: Essential oils of plant samples were extracted by hydro-distillation method using Clevenger-type apparatus. Distilled water was added to the weighed dry plant samples (1:10 w/v) and distilled for 3 h. The extracted essential oils were stored until the start of experiments (45).

III. GC and GC-MS analysis: GC analyses of *Salvia absconditiflora* essential oils were done by Agilent brand 7890A model GC. Oil was diluted in acetone (1:10) and injected in a BPX90 column (100m x 0.25mm × 0.25µm) separate. The carrier gas was helium at 5 psi inlet pressure. Injector and detector (FID) temperatures were 120 and 254 °C, respectively. The column temperature was programmed from 60 to 120 °C at 5°C/min with the initial and final temperatures held for 3 and 16 min. Diluted samples of 1.0 µL were injected in the split (1:5) mode. Total analysis time was 43 min. Quantitative data were obtained electronically from FID area percent data without the use of correction factors.

MS results were compared and identified with the computer mass libraries Whiley and NIST. The relative peak area percentages of compounds were calculated based on the FID data.

IV. Bioassay for herbicidal effects: In petri dishes (9 cm dia), 25-seeds of *Lepidum sativum* and *Amaranthus retroflexus* were sown equidistance with 2 layers of filter paper, moistened with 5 ml distilled water per petri dish. Essential oils were used as gaseous form vapour due to their low water solubility. The essential oils [0 (control), 0.5, 1.0, 5.0, 10 and 20 µl/petri dish] were dripped using a micropipette on drying paper glued to the covers of the petri dishes, the petri dishes were immediately closed and wrapped tightly with parafilm (34). Petri dishes were incubated [24± 1 ºC and 12 h light-12 h dark] 4 weeks (26,29,39). The treatments were replicated 4-times in completely randomised Design. Germination rate, radicle and shoot lengths were determined after 28^{th} days.

V. Bioassay for fungicidal effects: Plant pathogenic fungi *Sclerotinia sclerotiorum* and *Alternaria solani* were obtained from the stock cultures in Phyto-clinical laboratories of our Department. Young fungus cultures of these stock cultures, grown at 25 ±2 ºC in 90 mm petri dishes containing 20 ml potato dextrose agar (PDA) were used in the experiment. The prepared PDAs were autoclaved and cooled to 40 ºC and transferred to petri dishes (60 mm dia). Sterile filter paper (5 mm dia) was adhered to the covers of PDA transferred petri dishes. The mycelium from 7-days old fungus cultures were transferred into petri dishes. The essential oils at 0.5, 1.0, 1.5, 2.0, 5.0, 7.0, 10 and 20 µl/petri dish doses were dripped on the filter papers stuck to the covers of petri dishes using micropipettes. Fungus cultures were incubated for 7 days at 25 ± 2 ºC, thereafter inoculation and fungal growth was recorded (20). The treatments were replicated 4-times in completely randomised Design. The inhibition in growth compared control was calculated as under (36).

$$I=100 \times (DC - DT)/DC$$

Where, I: Inhibition (%) compared to control (Mycelium growth), DC: Mycelium growth in control, DT: Mycelium growth in plant extract treatments.

VI. Soil Physico-chemical Properties: Soil samples collected from 0-20 cm depth were analyzed for soil texture, water saturation, PH, Organic matter, K_2O, P_2O_5, total salt and $CaCo_3$.

Collection of Soil Samples: Soil samples were collected and prepared for analysis as per (25). Soil samples were sieved through 2 mm sieve before laboratory analysis.

(i). Soil Texture*:* Particle size distribution of soil samples was determined according to the hydrometer method as per (10).

(ii). Water saturation percentage*:* Soil samples were saturated with pure water based on the principles as per (13).

(iii). Soil pH: Soil pH was determined in the saturation paste using a pH meter as reported by (47).

(iv). Electrical Conductivity: The electrical conductivity of soil samples was measured in the saturation extract by an electrical conductivity meter as per (48).

(v). Total lime: Total calcium carbonate content of soil samples was calculated by the volume of CO_2 in the Scheibler calcimeter (20).

(vi). Organic matter: The modified form of Walkley Black method was used as per (33).

(vii). Available phosphorus (P): Available P concentration of soil samples was determined by the method as per (31).

(viii). Exchangeable potassium (K): The potassium, which is one of the exchangeable cations, concentration of soil samples was extracted by 1N (pH 7.0) ammonium acetate as described by (22) and the extraction was analyzed by a flame spectrophotometer.

VII. Statistical Analysis of Data: Significance of the differences between the treatments was assessed by analysis of variance (ANOVA) test and the mean values were compared using the DUNCAN test. The statistical analyses were performed using SPSS (Ver.15.0, SPSS) software.

RESULTS AND DISCUSSION

Soil properties and Chemical composition

S. absconditiflora samples were collected from 10 different locations of Kırşehir, from different altitudes (Table 1). The soil of the research area was alkaline clay loam, calcareous $CaCO_3$ content: 3.78 to 67.45 %, soil pH : 7.58 to 8.30, Organic matter: 1.39 % to3.71%, Potassium : 88.47 kg da^{-1} K_2O, poor in phosphorus 4.06 kg da^{-1} P_2O_5 (Table 2).

Table 2. Physico-chemical properties of soil samples collected from different locations of *Salvia absconditiflora* populations

Sample Number	Locations	Saturation water (%)	pH	Total salt (%)	$CaCO_3$ (%)	Organic matter (%)	K_2O ($kgda^{-1}$)	P_2O_5 ($kgda^{-1}$)
1	Çiçekdağ entry	72.6	8.25	0.015	67.454	1.871	113.589	3.256
2	Centry/Campus	54.50	7.58	0.018	26.85	1.79	65.52	2.01
3	Akçakent/ Hamzabey Vill.	58.3	8.09	0.008	14.074	3.501	98.766	3.914
4	Kaman exit	52.8	7.69	0.009	3.776	3.712	55.206	11.553
5	Mucur exit	62.7	8.22	0.015	22.313	1.6	160.02	4.573
6	Akçakent entry	61.6	8.3	0.010	27.806	1.509	73.205	1.807
7	Akpınar	59.95	7.91	0.011	3.776	2.777	91.053	1.543
8	Çiçekdağ exit	67.1	8.28	0.014	31.238	2.656	125.84	4.046
9	Kaman-Sarıyahşi	42.9	8.16	0.007	7.037	1.388	88.028	2.07
10	Mucur entry	50.6	8.04	0.012	49.089	1.569	72.146	6.68

The distribution of plants even of same specie depends on the soil characteristics and ecological factors. Different soil characteristics, altitudes, and ecological factors may cause differences in morphological and chemical structures of plants. Soil pH (5.3-8.2), organic matter (2.3-7.2%), and sand (38.7-%60.7%) contents of the areas where *Salvia desoleana* populations were highly variable. *Salvia* species grow on rocky slopes, alkaline soils and lime rich soils with low groundwater levels (38).

Chemical composition: In the essential oils of *S. absconditiflora* plants collected from different locations, 36-components were identified. Essential oil composition varied among populations (Table 3). Camphor (0.52-58.64%), Bicyclo [2.2.1] Heptan-2-One, 1.7.7 (21.94-30.16%) and viridiflorol (3.42-25.2%) were the main components according to GC/MS analysis. The Bicyclo (2.2.1) Heptane-2-One in *S. absconditiflora* essential oil collected from the regions 1,4,5 and 10; Viridiflorol in the region 2 and Camphor in the sampling locations of 3,6,7,8 and 9 were the main components (Table 3). Eucalyptol (27.64%), camphor (29.87%), α-pinene (11.91%) and borneol (6.57%), were identified as the primary components out of total 32 components of *S. cryptantha* essential oil collected from Tokat province (53). Identified camphor (18.1%), 1,8-cineole (eucalyptol) (17.8%) and bornyl acetate (11.4%) as the primary components of total 54 components of *S. cryptantha* essential oil (1).

Similarly, camphor (19.1%), 1,8-cineole (16.4%), borneol (11.9%), viridiflorol (11.5%) in naturally distributed *S. cryptantha* essential oil in Kayseri (2) and Valence (31,80%), 1,8-cineole (17.43%), camphor (13.73%) and Isoberneol (10.79%) in *S. cryptantha* essential oil collected from Konya were identified as the primary components (24). The predominant compounds of *Salvia cryptantha* essential oil were determined as 1.8-cineole (21%), camphor (19.1%), α-pinene (12.5%), camphene (8.7%) (15). The identified 13 components in the essential oil of above-ground parts of *S. cryptantha* collected from the Ereğli-Ivriz region and 10 components in the flower (6). In the same study, Valencene (24.34-26.53%), 1,8-Cineole (30.38-36.28%) and camphor (12.29-14.72%) were reported as the main components. Viridiflorol (21.4%) was also reported in the essential oil of *Salvia crypthanta* (28). The vegetative conditions (flowering time, harvesting time, post-harvest processes and drying conditions), analysis methods and geographic, climatic and environmental factors of plants grown resulted in the differences for the essential oil compositions obtained in the present study and as well as in other studies (3,32,41,42). The essential oil compositions of plants are also closely related to soil properties (pH, organic matter, salinity, etc.) where plants are grown (38). In this study, the soil properties of the sampling locations where *S. absconditiflora* populations were distributed significantly varied (Table 2) and therefore differences in essential oil compositions were observed.

Allelopathic potential

The seed germination, root and shoot growth of *Amaranthus retroflexus* L. and *Lepidium sativum* L. plants were adversely affected by *S. absconditiflora* essential oil. The effects differed depending on the dose of essential oil and the test plant, and the negative effect increased with the increased dose. The increase in *S. absconditiflora* essential oil dose decreased the seeds germination and seedlings root and shoot growth of *Lepidum sativum* (cress) than control.

Table 3. Chemicals Constituents (%)identified by GCMS in essential oil of *Salvia absconditiflora*

No.	RT*	RRI**	Compounds	Sıte/Sample Number									
				1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1	12.510	1387	β-caryophyllene	1.6	-	-	-	-	-	6.92	0.17	-	-
2	12.546	1394	Valencene	0.27	-	-	-	-	-	-	2.72	1.86	-
3	13.642	1405	Naphtlalene	-	-	9.5	0.24	1.31		6.82	0.23	3.96	-
4	12.956	1417	Muurolene < Gamma->	-	6.31	-	12.93	3.37	7.22	-	4.03	-	2.57
5	13.529	1427	Bisabolene	8.25	-	-	-	16	-	-	-	-	10.49
6	13.540	1428	Gurjunene<Beta-	-	16.94	-	-	-	-	-	-	-	-
7	14.765	1429	Camphor	20.71	10.52	58.64	16.9	16.34	53.18	37.91	55.64	47.33	12.44
8	14.971	1433	Bicyclo[2.2.1]Heptan-2-One, 1,7,7	29.06	21.94	-	28.12	30.16	-	-	-	-	24.45
9	15.966	1453	Myrtenol	-	-	-	-	-	5.44	-	2.66	4.06	0.53
10	17.168	1475	n-eicosane	-	-	-	-	-	-	-	-	-	4.13
11	17.265	1478	Sesquisabinene hydrate	-	-	0.33	0.5	-	0.28	-	-	-	-
12	17.603	1482	Ledol	-	0.54	1.5	3.16	3.56	-	-	-	-	1.24
13	17.609	1484	Cubebol	0.52	-	-	-	0.3	-	-	-	-	-
14	18.799	1508	Germacrene D	1.64	-	0.65	0.41	-	-	-	1.07	-	-
15	19.417	1520	Viridiflorol	13.85	25.2	10.54	21.02	10.67	15.71	23.24	3.42	19.83	16.73
16	20.052	1532	Bicyclo[4.4.0]dec-1-ene	-	0.36	-	-	-	-	-	-	-	0.78
17	20.092	1534	Longifolene	0.92	-	-	-	-	-	-	1.6	1.01	-
18	20.315	1538	Alloaromadendrene oxide	-	-	1.57	0.32	-	-	-	-	-	-
19	20.555	1542	Spathulenol	5.02	1.92	-	0.48	-	0.75	0.97	-	-	3.48
20	20.590	1544	Caryophyllene oxide	-	-	2.39	2.1	2.62	3.47	7.74	5.59	3.29	-
21	21.253	1559	Cadinol<Alpha->	-	1.11	-	1.45	0.72	0.72	0.31	1.36	0.47	-
22	21.425	1560	Humulene epoxide II	-	-	3.43	-	-	-	-	-	-	1.16
23	21.849	1568	Azulene	-	-	1.38	-	-	-	-	-	-	0.39
24	21.894	1572	Eudesmol<Alpha->	1.96	1.82	-	1.43	1.64	1.43	1.27	2.36	1.11	1.35
25	22.117	1576	7-Methoxy-2-Methyl quinoline -5,8-Dione	0.3	0.34	-	-	0.51	-	-	-	-	-
26	22.264	1580	Eudesmol<Beta-	6.66	4.83	3.71	3.65	3.92	3.18	4	6.97	2.83	3.58
27	22.758	1588	Valeranone	4.79	3.58	2.52	2.57	4.17	2.83	3.43	3.13	5.2	6.58
28	23.245	1598	1H-Cycloprop[A] Naphthalen -6-Ol	0.48	0.34	0.66	0.35	-	0.45	1.3	1.67	0.86	-
29	23.479	1602	Valerenol	0.51	0.48	1.51	1.12	0.53	2.2	-	2.79	-	-
30	24.486	1621	Ledene oxide-(II)	-	-	0.89	0.95	0.32	1.31	-	1.56	1.06	-
31	24.488	1642	Vulgarol A	-	-	0.2	0.2	0.18	0.24	0.21	0.28	0.2	0.16
32	26.569	1663	Manool	1.6	1.97	-	-	0.22	-	0.12	-	1.55	2.72
33	27.159	1687	1-Naphthalenol	-	0.22	-	-	-	-	-	-	0.29	0.26
34	27.937	1689	1,2-Benzenedicar-boxylic acid	-	-	0.1	0.11	0.15	0	0.2	0.11	-	-
35	30.780	1746	9H-Benzimidazol [1.2-d][1.2.3]triazol	-	0.19	-	-	0.15	-	-	-	-	0.15
36	35.003	1826	Abietal	-	-	-	0.27	-	0.18	-	0.21	0.23	-
Total				**98.14**	**98.61**	**99.52**	**98.28**	**96.84**	**98.59**	**94.436**	**97.57**	**95.94**	**93.19**

*RT: Retention times **RRI: Relative Retention Indices

The essential oil at 10 µl/petri dish decreased the germination of cress seeds by 80% than control, while germination was completely inhibited at 20 µl/petri dish dose (Figure 3, Figure 5). The growth of seedlings of cress sprout was decreased by 84.44 % at 10 µl/petri dish essential oil dose, while 20 µl/petri dose completely inhibited the growth. At 10 µl/petri dose, the root growth was inhibited drastically by 97.88 %, whereas, the root growth was completely inhibited at 20 µl/petri dose (Figure 4, Figure 5). *S. absconditiflora* essential oil was phytotoxic to seeds germination of cress but the inhibitory effect was lower than *A. retroflexus*.

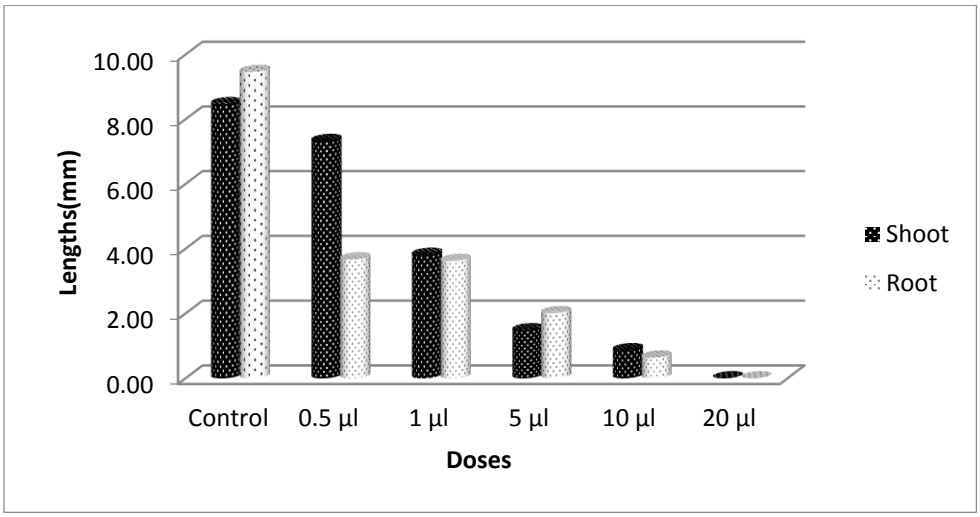

Figure 2. Effects of *Salvia absconditiflora* essential oil on root and shoot lengths of *Amaranthus retroflexus*

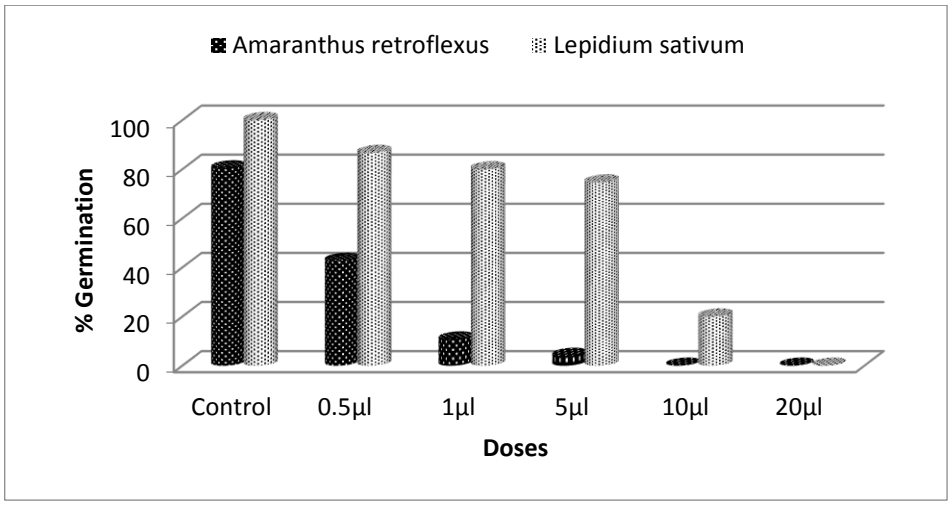

Figure 3. Effects of *Salvia absconditiflora* essential oil on germination % of the test plants

The *S. absconditiflora* essential oil decreased the root and shoot growth of *A. retroflexus* at higher doses than control. Its essential oil was very phytotoxic to seed germination of *A. retroflexus*. The essential oil at 5 µl/petri dose inhibited the seed germination of *A. retroflexus* by 53.10 % than control treatment and the seed germination completely inhibited at 20 µl/petri dose (Figure 3, Figure 5). The 10 µl/petri dose of essential oil drastically inhibited (89.73 %) the shoot growth of *A. retroflexus* than control. While 20 µl/petri dose completely inhibited the shoot growth. Similarly, the 10 µl/petri dose drastically inhibited (92.33 %) the root root growth, while root growth was completely inhibited at 20 µl/petri dose (Figure 2, Figure 5).

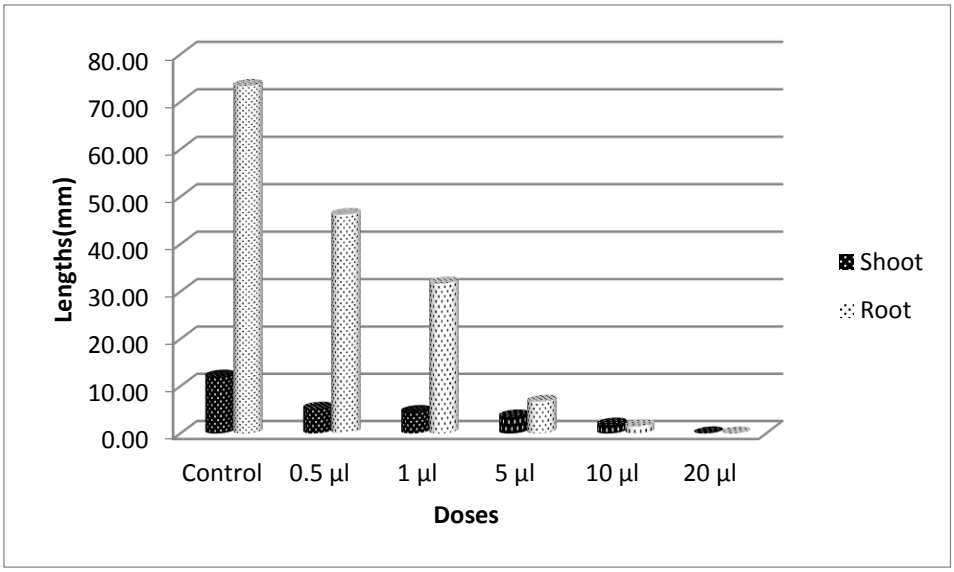

Figure 4. Effects of *Salvia absconditiflora* essential oil on root and shoot lengths of *Lepidum sativum*

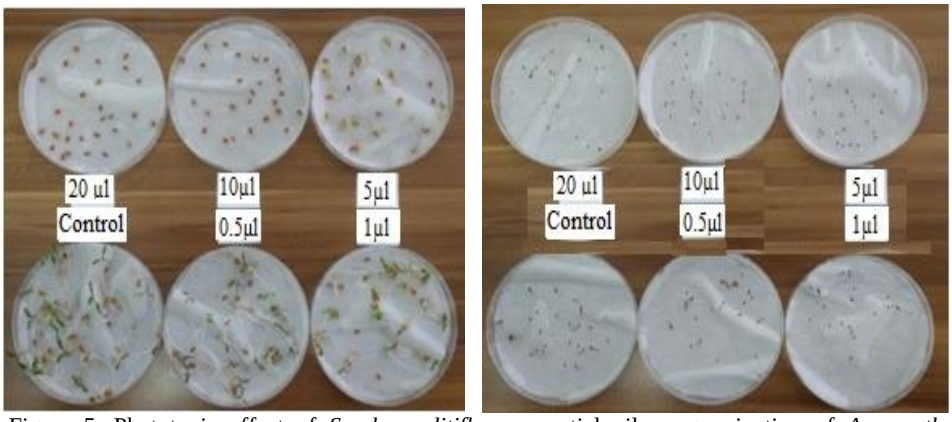

Figure 5. Phytotoxic effect of *S. absconditiflora* essential oil on germination of *Amaranthus retroflexus* and *Lepidum sativum* plants (7th day).

The phytotoxic effects of above-ground exudates of *Salvia namaensis* Schinz, *S. fallax* Fernald, *S. disermas* L., *S. chamaedryoides* Cav., *S. confertiflora* Pohl., *S. x jamensis* J. Compton, *S. bunchananii* Hedge, *S. wargneriana* Polak, *S. scabra* Linn.fil., *S. miniata* Fernald, *S. cacaliaefolia* Benth., *S. adenophora* Fernald, *S. rutilans* Carriere species on *Papaver rhoeas* L. and *Avena sativa* L. have been reported (8). Similarly, it indicated the inhibitory effects of *Salvia officinalis* essential oil on seed germination and root growth of *Lepidium sativum* L.(cress) (9). The methanol extracts obtained from *Salvia macrochlamys* Boiss. et Kotschy aboveground inhibited the germination of *Portulaca oleracea* seeds (18). In this study, antifungal and allelopathic effects of *S. absconditiflora* essential oil have been demonstrated. Allelopathic potential of dried leaves of *Salvia officinalis* L. reported on *Lycopersicon esculentum* Mill. (tomato), *Panicum maximum* Jacq. (guinea grass) and *Salvia hispanica* L. (chia) in greenhouse condition (12). In another study, Allelopathic effect of *Salvia plebia* R. Brown are reported on growth and germination of *Zea mays* var. 30-25 Hybrid, *Triticum aestivum* var. Pirsabak-04 and *Sorghum bicolor* L. plant (23).

Antifungal potential

The efficacy of *S. absconditiflora* essential oil on plant pathogens *Sclerotinia sclerotiorum* and *Alternaria solani* fungi was investigated *in-vitro*. The *S. cryptantha* essential oil has slight phytotoxic effects on the mycelium growth of *S. sclerotiorum*. The mycelium growth was inhibited by 9.3 % with 10 µl/petri dish dose, whereas the mycelium growth was completely inhibited with 20 µl/petri dish dose. The essential oil had significantly influenced the sclerot formation of the *S. sclerotiorum* pathogen. Accordingly, sclerot formation of the pathogen was completely inhibited at 7 µl/petri dose (Table 4, Figure 6, Figure 7).

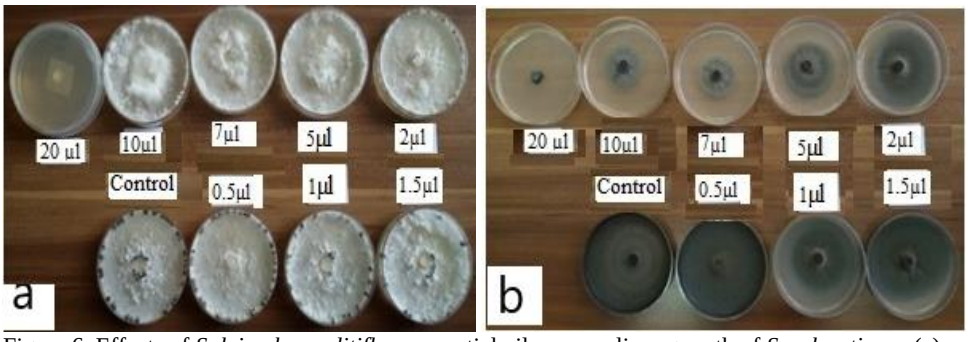

Figure 6. Effects of *Salvia absconditiflora* essential oil on mycelium growth of *S. sclerotiorum*(a) and *A. solani*(b) pathogens (7th day)

In contrast to the *S. sclerotiorum* pathogen, *Salvia absconditiflora* essential oil showed higher antifungal effects against the *Alternaria solani* pathogen. The effects of essential oil increased in relation to the increase in application dose of essential oil. *Salvia absconditiflora* essential oil inhibited the *A. solani* mycelium growth by 54.40v% with at 10 µl/petri dose compared to control and *A. solani* mycelium growth was completely inhibited at 20 µl/petri dose (Table 4, Figure 6).

Table 4. Effects of *Salvia absconditiflora* essential oil on mycelium growth of *S. sclerotiorum* and *A. solani* pathogens

Doses(µl)	Control	0.5	1	1.5	2	5	7	10	20
S. sclerotiorum	60.00± 0.00^{a*}	60.00± 0.00^{a}	60.00± 0.00^{a}	60.00± 0.00^{a}	60.00± 0.00^{a}	60.00± 0.00^{a}	60.00± 0.00^{a}	54.42± 0.08^{a}	0.00± 0.00^{b}
A. solani	60.00± 0.00^{a}	60.00± 0.00^{a}	56.90± 3.09^{a}	54.74± 2.46^{ab}	47.98± 0.75^{bc}	41.89± 2.75^{c}	34.02± 4.36^{d}	27.36± 0.27^{d}	0.00b± 0.00^{e}

*Means in the same column with the same letter were not significantly different by ANOVA (a = 0.05)

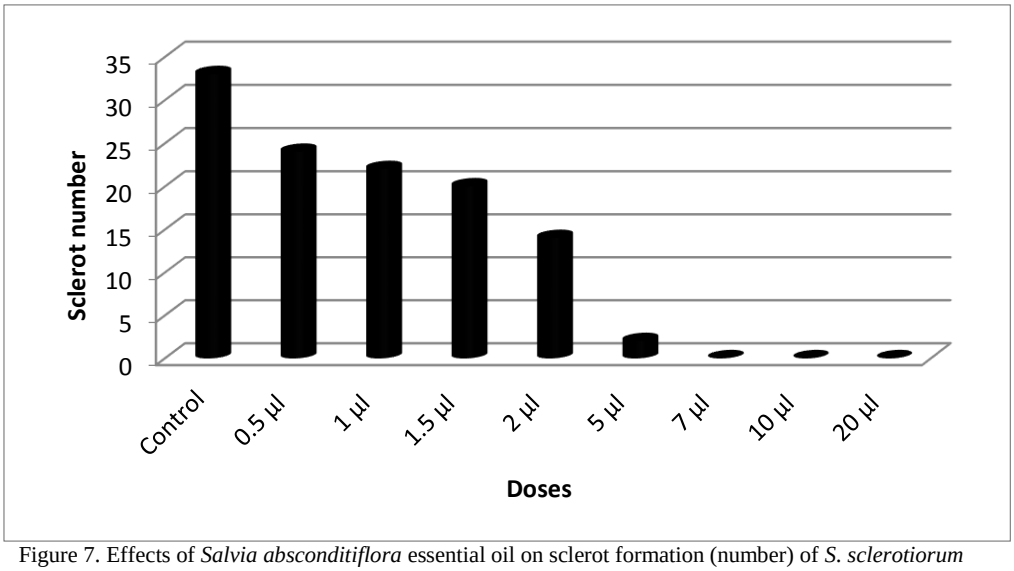

Figure 7. Effects of *Salvia absconditiflora* essential oil on sclerot formation (number) of *S. sclerotiorum*

The results demonstrated that *Salvia absconditiflora* has antifungal and allelopathic activity. Biological activity of *Salvia absconditiflora* essential oil and extracts on different insects, pathogens and test plants have also been reported in other studies. Plant extracts of *S. absconditiflora* were effective on gram-positive bacteria while ineffective on gram-negative bacteria and *Candida albicans* (50). The *S. absconditiflora* essential oil and methanol extract have antimicrobial and antioxidant activities (46). The *S. absconditiflora* essential oil showed insecticidal activity on two important pests, *Sitophilus granarius* L. and *S. oryzae* L. (27). The biological activity of *Salvia* species has been revealed in many studies. Similar results were found in antifungal studies with other species of Salvia. *Salvia officinalis* essential oil has antifungal effects on *Botrytis cinerea* and *Fusarium* sp. (51,52). Previous investigations on other *Salvia* spp. reported the antifungal activity of *S. somalensis* and *S. dolomitica* essential oils against *Aspergillus niger*, *Aspergillus flavus*, *Candida albicans* and others(17). In another study, extracts of *Salvia rhytidea* has been demonstrated the antifungal activity against different *Candida isolates* (40). Essential oils of *Salvia macrochlamys* and *Salvia recognita* were non-selective in inhibiting the growth and development of reproductive stroma of the plant pathogens *Colletotrichum fragariae*, *Colletotrichum acutatum* and *Colletotrichum gloeosporioides* (44).

CONCLUSIONS

The study showed that the essential oil compositions in *Salvia absconditiflora* populations vary depending on the location and soil characteristics. *S. absconditiflora* plant showed antifungal effects on *S. sclerotiorum* and *A. solani* pathogens and allelopathic effects on *Amaranthus retroflexus* and *Lepidum sativum* plants. This and similar studies will help to develop natural pesticides with the potential to replace synthetic pesticides.

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REFERENCES

1. Akgul, A., Ozcan, M., Chialva, F. and Monguzzi, F. (1999). Essential oils of four Turkish wild-growing Labiatae herbs: *Salvia cryptantha* Montbr. et Auch., *Satureja cuneifolia* Ten., *Thymbra spicata* L. and *Thymus cilicicus* Boiss. et Bal., *Journal of Essential Oil Research* **1**(2): 209-214.
2. Akin, M., Demirci, B., Bagci, Y. and Baser, K.H.C. (2010). Antibacterial activity and composition of the essential oils of two endemic *Salvia sp*. from Turkey. *African Journal of Biotechnology* **9** (15): 2322-2327.
3. Alizadeh, A. (2013). Essential oil constituents, antioxidant and antimicrobial activities of *Salvia virgata* Jacq. from Iran. *Journal of Essential Oil Bearing Plants* **16** (2): 172-182.
4. Al-Qudah, M., Al-Jaber, H., Zarga, M.H.A. and Orabi, S.T.A. **(**2014). Flavonoid and phenolic compounds from *Salvia palaestina* L., growing wild in Jordan and their antioxidant activities, *Phytochemistry* **99**:115-120.
5. Belen, V. (2012). *Salvia pilifera Montbret & Aucher Ex Bentham Collected from Different Areas Populatıons Variations and Analysis of the Essential Oil Components*. Kahramanmaraş Sütçü İmam University, Institute for Graduate Studies in Science and Technology, Department of Biyology, (Master Thesis) Pp. 40.
6. Bingol, U., Cosge, B., Ipek, A., Gurbuz, B. and Geven, F.G. (2009). Identification of essential oil components of *Salvia cryptantha* Montbret & Aucher ex Bentham, growing wild in Turkey. *Asian Journal of Chemistry*, **21** (5), 3836-3840.
7. Bisio, A., Damonte, G., Fraternale, D., Giacomelli, E., Salis, A, Romussi, G., Cafaggi, S., Ricci, D. and Tommasi, N.D. **(**2011). Phytotoxic clerodane diterpenes from *Salvia miniata* Fernald (Lamiaceae). *Phytochemistry* **72**: 265-275.
8. Bisio, A., Fraternale, D., Giacomini, M., Giacomelli, E., Pivetti, S., Russo, E., Caviglioli, G., Romussi, G., Ricci, D. and Tommasi, N.D. **(**2010). Phytotoxicity of *Salvia* spp. exudates. *Crop Protection* **29**(12): 1434-1446.
9. Bouajaj, S., Benyamma, A., Bouamama, H., Romane, A., Falconieri, D., Piras, A., Marongiu, B. (2013). Antibacterial, allelopathic and antioxidant activities of essential oil of *Salvia officinalis* L. growing wild in the Atlas Mountains of Morocco. *Natural Product Research* **27** (18):1673-1676.
10. Bouyocous, G.L. (1951). A re-calibration of hydrometer method for making mechanical analysis of soils. *Agronomy Journal* **43**; s.434-438.
11. Cantino, P.D., Harley, R.M. and Wagstaff, S.J. **(**1992). Genera of Lamiaceae: status and classification. In: *Advances in Labiate Science* (Eds., R.M. Harley and T. Reynolds). Pp. 511Â-522. Royal Botanic Gardens, Kew.
12. Cruz-Silva, C.T.A., Nóbrega, L.H.P., Dellagostin, S.M. and Silva, C.F.G. (2016). *Salvia officinalis* L. coverage on plants development. *Rev. Bras. Pl. Med., Campinas* **18**(2): 488-493.
13. Demiralay, I. (1993). *Soil Physical Analysis*. Ataturk University Faculty of Agriculture Publications, Erzurum No: **143**: pp. 131.
14. Demirci, B., Başer, K.H.C. and Yıldız, B. **(**2003). Bahçecioğlu, Composition of the essential oils of six endemic *Salvia* spp. from Turkey. *Flavour and Fragrance Journal* **18**: 116-121**.**

15. Dogan, G., Hayta, S., Demirpolat, A. and Bagci, E. (2017). Composition of the essential oil of endemic *Salvia cryptantha* (Lamiaceae) Montbret & Aucher Ex Bentham from Turkey. *Hacettepe J. Biol. & Chem*. **45** (3): 315-320.
16. Durling, N.E., Catchpole, O.J., Grey, J.B., Webby, R.F., Mitchell, K.A., Foo, L.Y. and Perry, N.B. **(**2007). Extraction of phenolics and essential oil from dried sage (*Salvia officinalis*) using ethanol-water mixtures. *Food Chemistry* **101**: 1417-1424.
17. Ebani, V.V., Nardoni, S., Bertelloni, F., Giovanelli, S., Ruffoni, B., D'Ascenzi, C., Pistelli, L. and Mancianti, F. (2018). Activity of *Salvia dolomitica* and *Salvia somalensis* essential oils against bacteria, molds and yeasts. *Molecules* **23**: 396.
18. Erez, M.E. and Fidan, M. (2015). Allelopathic effects of Sage (*Salvia macrochlamys*) extract on germination of *Portulaca oleracea* seeds. *Allelopathy Journal* **35** (2): 285-296.
19. Gulcur, F. (1974). *Physical and Chemical Analysis Methods of Soil*. Istanbul University Faculty of Forestry Publications, No: **201.** İstanbul.
20. Hadizadeh, I., Peivastegan, B. and Hamzehzarghani, H. (2009). Antifungal activity of essential oils from some medicinal plants of Iran against *Alternaria alternate*. *American Journal of Applied Sciences* **6**(5): 857-861.
21. Harley, R.M., Atkins, S., Budantsev, A., Cantino, P.D., Conn, B.J., Grayer, R., Harley, M.M., de Kok, R., Krestovskaja, T., Morales, R., Paton, A.J., Ryding, O. and Upson, T. (2004). Labiatae. In: *The Families and Genera of Vascular Plants* (Ed., K. Kubitzki), **Vol. 7:** 167-275**.** Springer-Verlag, Berlin.
22. Helmke, P.A. and Sparks, D.L. (1996). Lithium, Sodium, Potassium, Rubidium, and Calcium, In: *Methods of Soil Analysis, Chemical Methods* (Ed. D.L. Sparks), SSSA Book Series Number 5, SSSA., Madison, Part **3**: 551-574.
23. Husna, H., Shah, M., Sayyed, A. and Ismail, I. (2016). Allelopathic effects of *Salvia plebia* R. Brown on germination and growth of *Zea mays* var. 30-25 Hybrid, *Triticum astivum* var. Pirsabak-04 and *Sorghum bicolor* L. *J. Appl. Environ. Biol. Sci*. **6**(4): 93-104.
24. Ipek, A., Gurbuz, B., Bingol, M.U., Geven, F., Akgul, G., Rezaeieh, K.A.P. and Cosge, B. (2012). Comparison of essential oil components of wild and field grown *Salvia cryptantha* Montbert & Aucher ex Benthan, in Turkey. *Türk J. Agric. For*., **36**: 668-672.
25. Kacar, B. (1995). *Soil Analysis. Chemical Analysis of Plant and Soil*: III. Ankara University Faculty of Agriculture Education Research and Development Foundation Publications, Ankara No: **3**: Pp. 705.
26. Kadioglu, I. (2004). Effects of hearleaf cocklebur (*Xanthium strumarium* L.) extracts on some crops and weeds. *Asian Journal of Plant Sciences* **3**(6): 696-700.
27. Karakoc, O.C., Tufekci, A.R., Demirtas, I. and Ipek, A. (2013). Insectisidal activities of extracts and essential oils of *Salvia tchihatcheffii* and *S. cryptantha* plants against two main storage pests. *Res J Agric Sci* (TABAD) **6**: 155-158.
28. Kizilkecili, O. (2007). Determining Antifungal, Antibacterial and Antituberculosi Activity of Methanol, Ethanol Extracts and Volatile Oils of *Salvia crypthanta* Montbret & Auchr ex Bentham and Salvia pomifera L. Species, Balıkesir Üniversity, Institute of Science, Depertment of Biology, MSc.Thesis, page: 69.
29. Kordali, S., Çakır, A., Akcin, T.A., Mete, E., Akcin, A., Aydın, T. and Kılıç, H. (2009). Antifungal and herbicidal properties of essential oils and n-hexane extracts of *Achillea gypsicola* Hub-Mor. and *Achillea biebersteinii* Afan. (Asteraceae). *Industrial Crops and Products* **29**: 562-570.
30. Koyuncu, O., Yaylacı, O.K., Oztürk, D., Erkara, I.P., Savaroglu, F., Akçoşkun, O. and Ardıc, M. (2010). Risk categories and ethnobotanical features of the Lamiaceae taxa growing naturally in Osmaneli (Bilecik/Turkey) and environs, *Biological Diversity and Conservation* **3**(3): 31-45.
31. Kuo, S.,(1996). Phosphorus, In: *Methods of Soil Analysis, Chemical Methods, SSSA Book Series Number 5* , (Ed. D.L. Sparks), SSSA., Madison, USA. Part **3**: 869-921.
32. Moadeli, S.N.V. and Rowshan, A. (2013). Comparison of the essential oil components in wild and cultivate population of *Salvia virgata*. *International Research Journal of Applied and Basic Science* **4** (2):337-340.
33. Nelson, D.W., Sommers, L.E. (1996). Total Carbon, Organic Carbon, and Organic Matter, In: *Method of Soil Analysis*: *Chemical Methods.* (Ed. D.L. Sparks), SSSA, Madison,USA. Part **3**: 961-1011.
34. Onen, H., Ozer, Z. and Telci, I. (2002). Bioherbicidal effects of some plant essential oils on different weed species,. *Journal of Plant Diseases and Protection*, (Special Issue XVIII) 597-605.
35. Ozer, H., Altun, A., Saraydın, S.U., Soylu, S., Goktas, S., Tuncer, E., Inan, D.S., Koksal, B., Temiz, T.K., Tepe, B., Sen, M., Karadayi, K. and Turan, M. **(**2013). Antitumoral effects of *Salvia absconditit flora* Greuter & Burdet syn. *Salvia cryptantha* Montbret & Aucher ex Benth. on Breast cancer. *Indian Journal of Traditional Knowledge* **12**(3): 390-397.

36. Pandey, D.K., Tripathi, N.N., Tripathi, R.D. and Dixit, S.N. (1982). Fungitoxic and phytotoxic properties of essential oil of *Hyptis suaveolens*, *Z. Pflanzenkrankheiten Pflanzenschutz* **89**: 344-349.
37. Poyraz, I.E. and Koca, F. (2006). Morphological Investigations on some Medicinal Salvia L. Species in Eskişehir, *Anadolu University Journal of Science and Technology* **7(2):** 443-450.
38. Rapposelli, E., Melito, S., Barmina, G.G., Foddai, M., Azara, E. and Scarpa, G.M. (2015). Relationship Between Soil and Essential Oil Profiles in *Salvia desoleana* Populations: Preliminary Results, *Natural Product Communications*, **10**(9):1615-1618.
39. Sadeghi, S., Rahnavard, A. and Ashrafi, Z. (2010). Response of wheat (*Triticum aestivum*) germination and growth of seedling to allelopathic potential of sunflower (*Helianthus annuus*) and barley (*Hordeum vulgare* L.) extracts. *Journal Agric Technol*., **6**: 573- 577.
40. Salari, S., Bakhshi, T., Sharififar, F., Naseri, A. and Almani, P.G.N. (2016). Evaluation of antifungal activity of standardized extract of *Salvia rhytidea* Benth. (Lamiaceae) against various *Candida* isolates. *Journal de Mycologie Médicale*, **26**(4):323-330.
41. Sefidkon, F. and Mirza, M. (1999). Chemical composition of the essential oils of two Salvia species from Iran, *Salvia virgata* Jacq. and *Salvia syriaca* L. *Flavour Fragr. J.* **14**: 45-46.
42. Senatore, F., De Fusco, R. and De Feo, V. (1997). Essential oils from *Salvia spp*.(Lamiaceae) I. Chemical composition of the essential oils from *Salvia glutinosa* L. growing wild in Southern Italy. *J. Essent. Oil Res*. **9**:151-157.
43. Suntar, I., Akkol, E.K., Senol, F.S., Keles, H. and Orhan, I.E. (2011). Investigating wound healing, tyrosinase inhibitory and antioxidant activities of the ethanol extracts of *Salvia cryptantha* and *Salvia cyanescens* using in vivo and in vitro experimental models. *Journal of Ethnopharmacology* **135**: 71-77.
44. Tabanca, N., Demirci, B., Baser, K.H.C., Aytac, Z., Khan, S.I., Jacob, M.R. and Wedge, D.E. (2006). Chemical composition and antifungal activity of *Salvia macrochlamys* and *Salvia recognita* essential oils. *J. Agric. Food Chem.*, **54**(18): 6593-6597.
45. Telci, I., Bayram, E., Yılmaz, G. and Avci, B. (2006). Variability in essential oil composition of Turkish basils (*Ocimum basilicum* L.). *Biochemical Systematics and Ecology* **34**: 489-497.
46. Tepe, B., Donmez, E., Unlu, M., Candan, F., Daferera, D., Vardar-Unlu, G., Polissiou, M. and Sokmen, A. (2004). Antimicrobial and antioxidative activities of the essential oils and methanol extracts of *Salvia cryptantha* (Montbret et Aucher ex Benth.) and *Salvia multicaulis* (Vahl). *Food Chemistry* **84:** 519-525.
47. Thomas, G.W. (1996). Soil pH and Soil Acidity. In: *Methods of Soil Analysis, Chemical Methods, Part 3* (Ed. D.L. Sparks) SSSA and ASA, Madison, 475-490.
48. Tuzuner, A. (1990). *Handbook of Soil and Water Analysis Laboratories*. Ministry of Agriculture, Forestry and Rural Affairs, TurkeyGeneral Directorate of Rural Services, 21-27.
49. Ulubelen, A., Miski, M., Neuman, P. and Mabry, T.J. **(**1979). Flavonoids of *Salvia tomentosa* (Labiatae). *Journal of Natural Products* **42**(3): 261-263.
50. Yigit, D. and Kandemir, A. (2002). Antimicrobial activity of some endemic plants (*Salvia cryptantha*, *Origanum acutidens*, *Thymus sipyleus* subsp. sipyleus), *Erzincan University Journal of Education Faculty* **4**(2): 77-81.
51. Yilar, M. and Kadıoglu, I. (2018). *Salvia* Species and their biological activities naturally distributed in Tokat Province, *Scholars Bulletin, Agriculture* **48**(2): 208-212.
52. Yilar, M. and Kadioglu, I. **(**2016). Antifungal activities of some *Salvia* species extracts on *Fusarium oxysporum* f sp radicis *lycopersici* mycelium growth *In-vitro*, *Egyptian Journal of Biological Pest Control* **26**(1): 115-118.
53. Yilar, M., Kadioglu, I. and Telci, I. (2018). Chemical composition and antifungal activity of *Salvia officinalis* (L.), *S. cryptantha* (Montbret et Aucher ex Benth.), *S. tomentosa* (Mill.) plant essential oils and extracts, *Fresenius Environmental Bulletin* **27**(3): 1695-1706.