Journal of Agricultural Chemistry and Environment, 2020, 9, 48-58
https://www.scirp.org/journal/jacen
ISSN Online: 2325-744X
ISSN Print: 2325-7458

Halophytic Species in Natural Areas Close to Agricultural Areas of Araban (Gaziantep, Turkey)

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How to cite this paper: Tunç, E., Tekin, M.S., Demir, M. and Tsegai, A.T. (2020) Halophytic Species in Natural Areas Close to Agricultural Areas of Araban (Gaziantep, Turkey). *Journal of Agricultural Chemistry and Environment*, **9**, 48-58.
https://doi.org/10.4236/jacen.2020.92005

Received: December 30, 2019
Accepted: April 19, 2020
Published: April 22, 2020

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Abstract

As a result of the global warming caused by increasing industrialization, changes in vegetation have occurred on the earth. Halophyte species have been observed in many areas including native vegetation and agricultural land due to increased drought and warming and also over irrigation during formation of secondary vegetation. Soil samples were taken seasonally from selected three areas (Timurlenk, Karapinar and Fakili) in Araban (Gaziantep Turkey) and the pH, electrical conductivity (EC), lime ($CaCO_3$), nitrogen (N), phosphorus (P), potassium (K), sodium (Na) and calcium (Ca) analyzes were performed in this samples. In addition, the presence of taxa known to be halophytes in these areas has been investigated. As a result of the analyses, it was found that there was no seasonal difference ($p > 0.05$), but there were significant differences between lime ($CaCO_3$), phosphorus (P), potassium (K) and calcium (Ca) among the localities ($p < 0.05$). *Alhagi pseudoalhagi* M. Bieb. was found in Timurlenk and Karapinar, *Salsola kali* spp. *ruthenica* Iljin was found in Timurlenk and *Juncus inflexus* L. was found in Timurlenk, Karapinar, Fakili. Although the soil is not salty, the presence of three different taxa that can tolerate the salt in three localities shows that the amount of salt in the soil may increase in time. The information presented in this study contributes to the salinization of soils and their effects on agriculture in the region.

Keywords

Soil Salinity, *Alhagi*, *Juncus*, *Salsola*, Agriculture, Gaziantep

1. Introduction

After the industrial revolution, our world became rapidly polluted. As a result, global warming has been caused due to the greenhouse gases accumulated in the atmosphere. Global warming affects not only natural vegetation but also agricultural lands all over the world [1] [2]. Drought threat which is manifested by the increase in temperature is one of the most important factors in the change of natural vegetation [3] [4] [5] [6].

Soils are at risk of salinization due to global warming [7]. Salination can also be caused by improper agricultural practices such as irrigation and fertilization [1] [8]. The world's salt-affected area is approximately 831 million hectares, and an estimated 397 to 434 million hectares of these are salty and sodic areas. However, it is 45 million ha under salinization which can be irrigated. This corresponds to approximately 20% of total irrigable areas [9].

Turkey has approximately 26.5 million hectares of potential agricultural land. Approximately 4.3 million ha of this area is known to be inefficient for various reasons. About 1.5 million ha of this area is under the risk of aridization due to global warming or anthropogenic reasons [3] [4] [10]. However, this corresponds to 2% of 1.5 million hectares of land resources in Turkey. Kaya *et al*. [10] reported that this constitutes 614 thousand hectares of low and 504 thousand hectares of land with high salt content. In the Southeastern Anatolia Region in the Irano-Turanian Phytogeographical Region, saline soils constitute 236 ha of a total of 6336 ha degraded soil area [4]. Over time, in such salinized areas plants that can tolerate soil salt can be seen.

Halophyte plants have the ability to tolerate salt and have developed different adaptations in this regard [7] [9]-[18]. Although there are many definitions of halophyte plants [17] [19], the most accepted definition is the definition by Flowers and Colmer [14]: They are plants that can perform life cycles (germination, growth, development, flowering, seed-giving and other metabolic activities) in areas with salt concentrations of 200 mM and above where 99% of glycophytes cannot survive [15] [20]. However, dicotyledon halophytes show optimal development at salt concentrations between 50 and 250 mM NaCl, while monocotyledons show optimal development in the absence of salt. If stimulated, Monocotyledon may also develop at 50 mM or less than halophytes [14] [21].

In the world, around 550 genera belonging to about 117 families and around 1560 halophyte species have been identified [3] and these species constitute 1% of the total number of plant species [14] [20]. In Turkey, it is known that there are over 300 halophytic species [21] and in Irano-Turanian Phytogeographic Region of Turkey, there are 34 families belonging to 88 genera and 137 halophytic species [4]. Asteraceae, Chenopodiaceae, Fabaceae and Liliaceae are the most common species in terms of the species they contain and the dominant genera belong to *Salsola*, *Chenopodium*, *Limonium*, *Alhagi* and *Allium* respectively [4].

Investigating the vegetative structure of soils at risk of wasteland is important in terms of improving agricultural production. For this reason, this study was conducted in the natural areas between the agricultural lands in the Araban district of Gaziantep and this study aimed to determine whether the soil is salted as a result of climatic changes and agricultural origin activities.

2. Material and Methods

2.1. Sample Collection

Three different vegetatively homogeneous natural areas (Timurlenk, Karapinar and Fakili) were selected in the Araban District of Gaziantep, close to the agricultural areas (**Figure 1**). In 2018, five different soil samples were taken from each area in four seasons: spring, summer, autumn and winter. The samples were brought to the laboratory and dried and passed through a 2 mm sieve for analysis. Samples were taken from plant vegetation in these areas and stored in herbarium and used for species identification.

2.2. Soil Analysis

Soil lime (%) analyzes were taken from dry soil samples by using calimeter according to Çağlar [22] and total nitrogen (N, %) were analyzed according to Bremner [23] using Kjeldahl.

For total phosphorus (ppm), it was determined by measuring the absorbance of samples and standards with the spectrophotometer according to Olsen *et al.* [24].

The electrical conductivity ($\mu S \cdot cm^{-1}$) was measured using a conductometer in soil-water (1:1) extract according to Kaçar [25] and the soil pH was determined using a pH meter in the soil water extract (1:1) according to [25].

The amount of sodium (Na), potassium (K) and calcium (Ca) of the sample extracts obtained by extraction of soil samples according to ammonium acetate method was determined by using flame photometer [25].

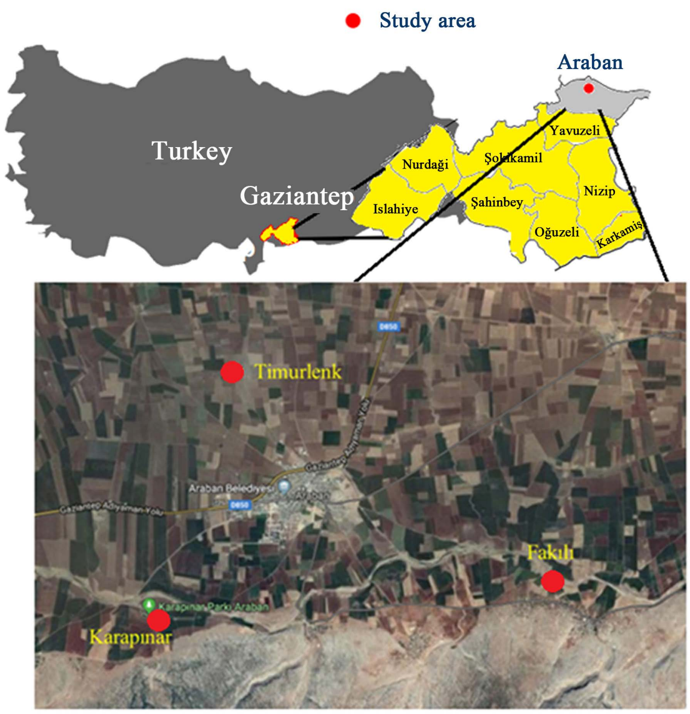

Figure 1. Maps of studied areas in Araban (Google maps, 2019).

2.3. Plant Systematics

The plant samples were pressed and dried and then species identified according to Davis [26].

2.4. Statistical Analysis

Statistical analysis was performed using SPSS version 22. One-way ANOVA and Tukey tests were applied to our results and $p < 0.05$ was considered statistically significant. Correlation analyzes were also performed.

3. Results

3.1. Results of Soil Analysis

Soil samples were taken from three different areas in Gaziantep's Araban district and different soil parameters of these samples were studied. According to this study, the annual average of the highest soil pH and lime (%) values were found in Timurlenk. The area with the highest annual average of sodium value is Fakili. Again, electrical conductivity (EC) ($\mu S \cdot m^{-1}$), nitrogen (%), phosphorus (ppm), potassium (ppm) and calcium (ppm) values are the highest annual average in Karapinar (**Table 1**).

The results of seasonal changes in pH are given in **Figure 2(e)**. Accordingly, the results of the pH of the soils taken from all three areas were obtained close to each other. The highest value was obtained in Timurlenk in summer and the lowest value was obtained in Karapinar in autumn. There was no statistically significant difference in pH depending on season and area ($p > 0.05$).

Figure 2(f) shows the soil EC ($\mu S \cdot cm^{-1}$) values in all three areas depending on the seasons. According to the values here, the highest value was obtained from Fakili in winter and the lowest value was determined from Fakili in autumn. As in pH, there was no statistical difference in electrical conductivity values depending on both seasonal and area ($p > 0.05$).

As a result of lime (%) analysis of soils, it was found that Timurlenk was higher than the other two areas (**Figure 2(g)**). The highest value was found in

Table 1. Annual average of soil parameters in studied areas.

	Timurlenk	Fakili	Karapinar
pH	8.25 ± 0.13^a	8.24 ± 0.05^a	8.02 ± 0.27^a
EC (µS/cm)	202.54 ± 11.33^a	203.58 ± 58.16^a	224.88 ± 30.21^a
Lime (%)	42.82 ± 2.09^a	17.11 ± 2.77^b	14.12 ± 3.03^b
Nitrogen (%)	0.13 ± 0.06^a	0.16 ± 0.07^a	0.17 ± 0.03^a
Phosphorus (ppm)	0.04 ± 0.01^c	0.11 ± 0.02^b	0.51 ± 0.04^a
Potassium (ppm)	359.96 ± 42.85^b	140.33 ± 50.27^c	$1.710.96 \pm 129.69^a$
Sodium (ppm)	7.67 ± 2.8^{ab}	11.19 ± 5.98^a	3.42 ± 0.96^b
Calcium (ppm)	81.95 ± 6.31^a	65.30 ± 3.88^b	89.56 ± 9.2^a

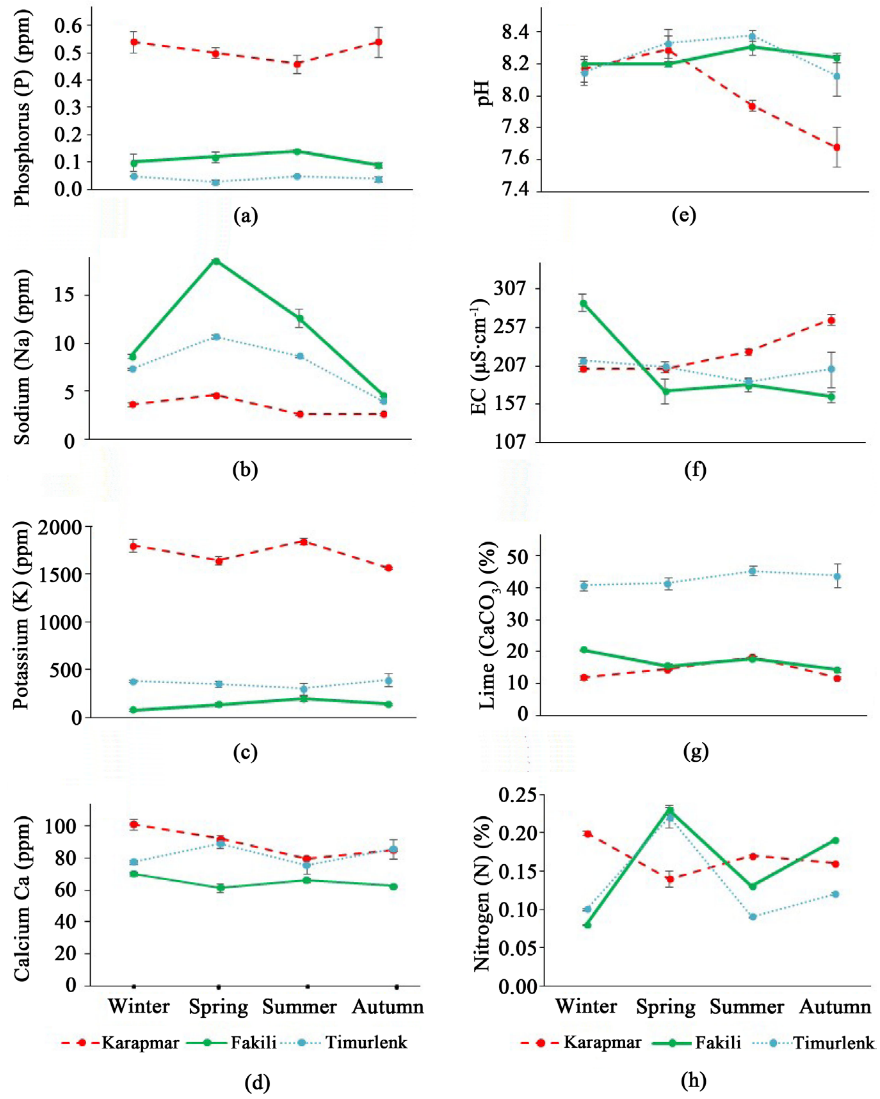

Figure 2. Seasonal variation of soil (a) Phosphorus (ppm); (b) Sodium (ppm); (c) Potassium (ppm); (d) Calcium (ppm); (e) Ph; (f) EC; (g) Lime; (h) Nitrogen in the studied areas No statistical significant difference was found ($p > 0.05$).

Timurlenk and the lowest value was found in Karapinar. No statistically significant difference was found between seasonal lime (%) values ($p > 0.05$). As a result of the Tukey test, it was found that there were significant differences between Timurlenk and the other two areas in the group evaluation ($p < 0.05$).

When the nitrogen (%) values were evaluated, the highest value was found in Fakili in spring and the lowest value was found in Fakili in winter Figure 2(h). Although seasonal changes were found to be higher than those in the other two areas, there was no significant difference in nitrogen (%) values depending on both seasonal and area ($p > 0.05$).

Phosphorus, which is one of the important nutrients for plant development, was found to have the highest value in Karapinar, followed in Fakili and Timurlenk respectively Figure 2(a). As a result of the analyses, the highest value was found in Karapinar in autumn and the lowest value was found in Timurlenk in spring. However, statistical analysis showed that there was no difference in terms of seasons ($p > 0.05$), but there were significant differences depending on the area ($p < 0.05$).

In terms of potassium, Karapinar was found to have considerably higher amounts than other areas. Karapinar is followed by Timurlenk and Fakili respectively. As can be seen from **Figure 2(c)**, the highest value was found in Karapinar in summer and the lowest value in Fakili in winter. However, it was found out that there was a difference in terms of potassium (ppm) depending on the area ($p < 0.05$). No seasonal difference was found ($p > 0.05$).

Although sodium values (**Figure 2(b)**) vary, it is generally found to be higher in the Fakili compared to the other two areas. However, sodium had the highest value in the Fakili in spring, while Karapinar had the lowest value in summer. Statistical analysis showed that there was no significant difference in both seasonal and area ($p > 0.05$).

Figure 2(d) also shows the seasonal variation of calcium (ppm) results. According to these results, the highest value was found in Karapinar in winter and the lowest value was in Fakili in spring. Although the results obtained from each area in all seasons were close to each other, statistical analysis showed that there was a significant difference in terms of calcium (ppm) depending on the area ($p < 0.05$). However, seasonal differences were not found in terms of calcium (ppm) ($p > 0.05$).

The results of Pearson correlation analysis are given in **Table 2**. The pH shows that there is an inverse relationship between soils electrical conductivity, nitrogen content, phosphorus, potassium, and calcium amounts, and the lime ratio is directly proportional to the amount of sodium. Electrical conductivity is inversely proportional to lime, nitrogen, sodium, phosphorus, potassium and calcium content. The lime ratio is inversely proportional to the nitrogen ratio, phosphorus and potassium, and is directly proportional to sodium and calcium. Again, this analysis shows that the nitrogen ratio is directly proportional to phosphorus, potassium, sodium and calcium. Phosphorus is inversely proportional to the amount of sodium and is directly proportional to potassium and calcium. Potassium is inversely proportional to sodium while calcium is inversely proportional to sodium.

Table 2. Pearson correlation coefficient of studied soil parameters (*$p < 0.05$, **$p < 0.01$).

	pH	EC ($\mu S \cdot cm^{-1}$)	Lime (%)	N (%)	P (ppm)	K (ppm)	Na (ppm)	Ca (ppm)
EC	−0.564							
Lime (%)	0.360	−0.121						
Nitrogen (%)	−0.089	−0.390	−0.389					
P (ppm)	−0.571	0.289	**−0.682***	0.239				
K (ppm)	−0.545	0.250	−0.457	0.212	**0.950****			
Na (ppm)	0.485	−0.337	0.091	0.207	−0.539	**−0.648***		
Ca (ppm)	−0.179	0.218	0.079	0.093	0.567	**0.710****	**−0.580***	

3.2. Result of Systematics

As a result of the taxonomic study, *Alhagi pseudalhagi* M. Bieb. of the Fabaceae (Legumes) family were found in Timurlenk and Karapinar. Also, *Salsola kali* spp. *ruthenica* Iljin from the Chenopodiaceae was found only in the Timurlenk area, while *Juncus inflexus* L. from Juncaceae was found to be in all three areas.

However, *Salsola kali* spp. *ruthenica* Iljin is not widespread in the area, it was observed in the area with a few individuals. Similarly, *Alhagi pseudalhagi* M. Bieb. had more individuals in the Karapinar than in the Timurlenk, but the individuals in the Timurlenk remained more stunted than those in the Karapinar. *Juncus articulatus* L., which was found in all three areas, was found to be at least in the Timurlenk and the highest number of individuals was found in the Fakili. These findings are given in Table 3.

4. Discussion

In all three fields, it was determined that it was quite high in terms of calcium and potassium values, although it was low in total sodium in soil samples analyzed, which is well below the soil salt concentrations of 200 mM NaCl used by Flowers and Colmer [14] in the definition of halophyte. *Alhagi pseudalhagi* M. Bieb., which is one of the plants of Irano-Turanian Phytogeographical Region, is a species resistant to salinity from common xerophyte and xerohalophytes in terrestrial saline areas [3] [8] [27] [28] [29]. This taxon was found both in Timurlenk and Karapinar in the study area. Although there are not many individuals, their presence in the two highest areas in terms of Ca and K suggest that this species is dependent on Ca and K salts. The abundance of *Alhagi pseudalhagi* at the three localities showed a direct relation to the concentration of K, which suggests that K greater effect for the result. Again, although Na has the lowest values in Karapinar, *Alhagi pseudalhagi* M. Bieb., showed the best development in Karapinar and this is a proof that this species can develop in less saline soils despite having high salt tolerance. In another study [30], *Alhagi pseudalhagi* M. Bieb. was detected in salt-free, salty, alkaline and salty-alkaline meadows supports this idea. Again, in the Harran Plain, it was found that another species *Alhagi manniferae* and *Prosopis fractae* Banks & Sol. formed associations in areas with similar pH and EC [10] [12]. In another study conducted in Kayseri, *Alhagi pseudalhagi* M. Bieb. and *Salsola kali* spp. *ruthenica* Iljin were found to be from weeds identified in sugar beet (*Beta vulgaris* L.) cultivation areas [31], which supports the findings of this study. However, contrary to the study of Akça and Işık [31], the number of individuals and thus the incidence and plant density

Table 3. Relative distribution and abundance of plants in the study area.

	Alhagi pseudalhagi	*Salsola kali*	*Juncus inflexus*
Timurlenk	+	+	+
Karapinar	++		++
Fakili			+++

of the plants in the investigated areas of this study are quite low.

Juncus articulatus L. belongs to the monocotyledon Juncaceae family that is cryptophyte and hygrohalophyte and has low salt tolerance. In this study it was observed in all three studied areas. It is a plant species with wide distribution in different climatic conditions in the world, from salt marshes, fresh water edges to badly irrigated lands [32]. The presence of this species has been previously reported in wetlands in the Karkamiş District of Gaziantep [33]. The fact that it is widespread in Fakili with the highest Na content is due to the fact that it is on the edge of Karapinar stream. However, it is controversial whether *Juncus* taxa is halophyte. Since this taxon is a monocotyledon which is abundant around water sources, they show their optimal development in salt-free areas. However, when stimulated, they can tolerate salt, even if not at high concentrations, as dicotyledons [14] [34] [35].

These taxa are used in bioremediation for removing the salinity of the land [9] and as a forage crop [20] [36], and it has importance in traditional pharmacy and modern industry. As a result, these three different taxa have been found in natural areas close to the regions where intensive agricultural activities are carried out. Their importance might have also contributed to their distribution in the area. For example, *Salsola* species are reported to be used in soap and detergent production [20], while *Juncus* species are reported to be used in mop production, paper industry, cellulose and nitrocellulose production [32]. In pharmaceuticals, *Salsola kali* L. also is reported to be used as a diuretic, stimulant and in the treatment of obstetrics and edema [20]. *Alhagi pseudalhagi* M. Bieb. has been reported to be used for the treatment of colitis, gastritis, gastric ulcers, hemorrhoids, dysentery, nasopharyngeal diseases, pharyngitis, cutaneous eruption and intestinal infection in traditional medicine [37]. In modern medicine, it has been found to have diuretic, litholytic, antirheumatic, antipyretic, anticancer, antiseptic, antidepressant effects and also treatment of kidney diseases [37] [38]. In addition, it is used frequently in Western Anatolia in Turkey for diarrhea. *Juncus* species have been found to have sedative, antipyretic, antioxidant, liver protective, antiviral, antimicrobial, anti-inflammatory, antieczemic and antitumor effects [32].

Two of these taxa are dicotyledon and one is monocotyledon taxa, although the soil is not salty, it is important that both dicotyledon can tolerate high amounts of salt. The presence of dicotyledon, *Alhagi pseudalhagi* M. Bieb. and *Salsola kali* spp. *ruthenica* Iljin could give evidence that the soils are salinized. In agreement to that a study conducted in the Harran Plain [12], found that halophytic areas increased by 387% between 1987 and 2000 due to excessive irrigation. As the time progress it is getting more evident that halophytic areas in this region will increase due to agriculture and global warming.

The most important situation observed during this study is the low number of individuals and their growth and development in these two taxa. Therefore, nutrient analysis in plants could not be performed. For the first time in this region, it is the first study to see whether halophyte plants are present in the vegetation and whether they are indicators of soil salinity. The data obtained with this study will form the basis for future studies in this direction.

Acknowledgements

This work was supported by Gaziantep University. All authors would like to thank Gaziantep University.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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