Evaluation of Soil Characteristics and Environmental Parameters of Arid-Semi Arid (Desert) Truffles from Eastern Turkey

Türkiye'nin Doğusunda Kurak-Yarı Kurak (Çöl) Trüflerin Toprak Özellikleri ve Çevresel Parametrelerinin Değerlendirmesi

Research Article

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ABSTRACT

The ecological characteristics of arid-semi arid truffles from Eastern Turkey were investigated. The habitat and climate characters of the collection sites were determined and soil samples from localities were analysed. The light strength, temperature, humidity, air flow and air velocity at the areas were recorded to be 17.7 klux to 303.9 klux, 7.8ºC to 24.3ºC, 11.9% to 43.2%, 3702.6 ft^3/min to 8941.6 ft^3/min, and 3.6 km/h to 16.9 km/h, respectively. Environmental parameters match the climatic requirements, which is normal for the region when spring is concerned. The soil samples contained 42.59% to 91.46% sand, 4.49% to 38.43% clay, 4.04% to 25.91% silt, 8.54% to 57.41% silt-clay. The soil types included sandy, sandy-loam, clay-loam, loam-sand, sandy-clay-loam types. The soil examples were understood to have alkaline characteristics and had a lime content. The level of organic material and nitrogen was low, whereas the amounts of phosphorus, potassium and sodium were high. Based on our studies and observations, it is possible to claim that habitat, host plant, climate, and soil types are as important as precipitation for the healthy growth of truffles.

Key Words
Arid-semi arid truffle, climatic parameters, *Picoa,* soil characteristics, *Terfezia.*

ÖZ

Türkiye'nin doğusunda kurak-yarı kurak trüflerin ekolojik özellikleri incelenmiştir. Toplama alanlarının habitatı ve iklim özellikleri belirlenmiş ve elde edilen toprak örnekleri analiz edilmiştir. Çalışılan alanların ışık şiddeti, sıcaklık, nem, hava debisi ve hava hızı sırasıyla 17.7-303.9 klux, 7.8-24.3ºC, %11.9-43.2, 3702.6-8941.6 ft^3/min ve 3.6-16.9 km/h olarak kaydedilmiştir. Ölçülen çevresel parametreler iklimsel ihtiyaçlarla örtüşmektedir. Ölçümler bölgenin bahar ayı koşulları itibariyle normal düzeydedir. Toprak örnekleri %42.59-91.46 kum, %4.49-38.43 kil, %4.04-25.91 toz, %8.54-57.41 toz-kil ve toprak tipleri ise kumlu, kumlu-balçık, killi-balçık, balçıklı-kum ve kumlu-killi-balçıklı toprak türünü içermektedir. Toprak örneklerinin alkali yapıya sahip olduğu ve kireç içerdiği anlaşılmıştır. Organik madde ve azot oranının düşük olduğu fakat fosfor, potasyum ve sodyum içeriğinin yüksek olduğu görülmüştür. İnceleme ve gözlemlerimize dayanarak kurak, yarı kurak ya da çöl trüflerin sağlıklı yetişmesi için yağış kadar habitat, mikorizal bitki, iklim ve toprak tiplerinin de önemli olduğu söylenebilir.

Anahtar Kelimeler
Kurak-yarı kurak trüfler, iklimsel parametreler, *Picoa,* toprak özellikleri, *Terfezia.*

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INTRODUCTION

Global warming has been destroying the habitat of living creatures, their area of distribution and the species. The excessive gathering of the species and their commercial use cause extinction. Overgathering is an important threat in Turkey. The decrease in the number of species has caused scientists to adopt new approaches to the subject today, and scientific research focusing on ecosystems, aiming at understanding their importance, have gained speed [1].

Earth is divided into different eco-geographic regions based on their climatic characteristics, and their plant and animal diversity. Anatolia is one of the unique places on earth in terms of its geological history and ecological characteristics, and it is a center for many species to take shelter and protect their genes. It also has a priviliged position in terms of its rich biodiversity because of it geographical location where three continents meet [2-4].

Truffles are edible hypogeous fruit bodies that go under the genera of fungi belonging to the class Ascomycetes G.Winter. *Terfezia* (Tul. & C.Tul) Tul. & C.Tul. (Pezizaceae Dumort.), *Tirmania* Chatin (Pezizaceae Dumort.), *Picoa* Vittad. (Pyronemataceae Corda), and *Tuber* P.Micheli ex. F.H Wigg (Tuberaceae Dumort.) are classified in different taxa in Pezizales J.Schrot [5]. These can be observed in most of the arid and semiarid zones of the Middle East and the Mediterranean Basin world. Desert truffle species including *Terfezia*, *Tirmania* and *Picoa* form mycorrhizae mainly on the roots of the plants belonging to the Cistaceae family, which include different species of the genus *Helianthemum* (L.) Miller [6-10].

Truffle types can grow in various areas depending on the habitat's climate, altitude, vegetation and the soil structure. Unfortunately, there is little data on the effects of climate change on truffle fruiting. In a similar way, the effects of environmental conditions on truffle growth in Turkey is also not well investigated [11], mainly because truffle fungi have received less attention than epigeous fungi, and other plants and animals [12].

This study presents investigations on bioecology of arid-semi arid truffles collected from the Elazığ-Malatya region of Turkey. The study focuses on the habitat description, and the climatic and soil characteristics of truffles, which are a mushroom type with high nutritious and economic value, analysed together with the characteristics of their distributional habitats.

MATERIALS and METHODS

Study Areas and Obtaining the Arid-Semi Arid (Desert) Truffles

According to Akyüz et al. [13] wild samples of fresh *Terfezia* and *Picoa* species were collected from the Malatya-Elazığ provincial border zone and its vicinity that cuts through the area around N 38° 19'-43' E 038° 19'-51' with an altitude of 690-1375 m.

Sampling and the Methods for Soil Analysis

Soil samples were taken from a depth of about 10-15 cm from the surface by means of a stainless steel crab during the fieldwork. These were air-dried in the laboratory under a heat of 25°C. The dried samples were first crushed with a wooden pestle, then screened through a 2 mm sieve, and finally analysed to determine some of the physical and chemical characteristics. The physico-chemical properties of the samples were determined with teh methods described below.

The distribution of soil texture types including sand, clay, and silt were analysed using the hydrometer method [14]. The $CaCO_3$ content was determined by the Scheibler calcimeter method [15]. For the amount of organic matter the methods modified by Walkley-Black [16,17] was used, and the total nitrogen amount was determined using the Kjeldahl digestion and distillation procedure [18]. The pH and electrical conductivity (mmhos/cm) were measured in water with a 1:2.5 ratio of soil solution [15,19]. The amount of phosphorus was calculated by the vanadomolybdate method of Murphy & Riley [20], and Na and K amounts were determined by using an atomic absorption spectroscopy device (AAS).

The Measurement of the Environmental Parameters

The illuminance level (klux), humidity (%), heat changing (°C), air velocity (km/h) and air flow (CFM, ft^3/min) of the area the truffle growth were

measured using a Geofennel FLM 400 Data lux meter, FHT 70 Datalog temperature and humidity calculator, and FTA 1 thermometer-anemometer, respectively.

RESULTS

Habitat and Other Characteristics

It was detected that arid and semi-arid truffle types grow in the study area from the beginning of March to the end of May, and rarely continue until mid-July (Figure 1a). In areas with sandy soil with low permeability, which dries quickly (Figures 1b-c, f), it is easier to locate truffles when the temperature is around ~10-23ºC. The soil bulges and cracks in these areas (Figure 1g-h), sometimes close to the soil surface. These fungi are taken out of soil by the locals, who use a tool with a pointed tip, as they know where these grow. At times when the soil surface does not crack, collection of truffles is conducted by ''domalan and kumi'' collectors (Figure 1ı), who hit the soil with sticks at areas around where H. salicifolium and rarely *H. ledifolium* mostly grow (Figures 1d-e), and who detect their location based on the differences in sound. On the other hand, truffles can be collected by using a digging tool in areas where the soil buldges and cracks after it becomes warmer following spring rains.

Truffle types can grow in this area abundantly based on the favourable climatic conditions. The area where this mushroom grows are barren lands with a sandy soil, where no woody plants, but

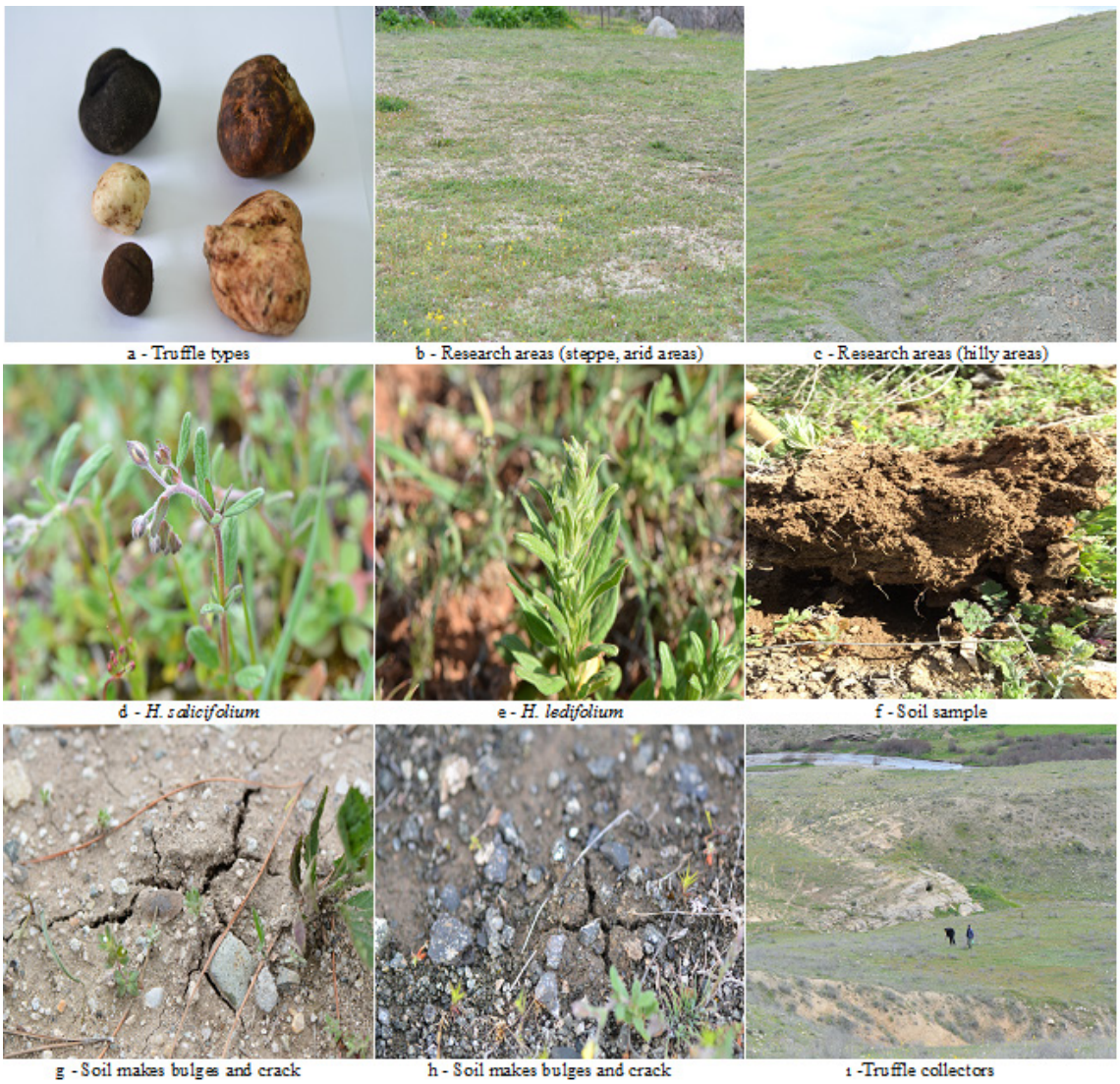

Figure 1. The truffle types, host plants, and soil samples etc. that were collected from the Elazığ-Malatya areas.

annual herbaceous plants grow. All truffle samples are generally known as ''kumi'' or ''domalan'' in the research area. The local names for *T. boudieri* include ''domalan, kumi'', ''kuş-karga mantarı, maf, makelik, maklik'' for *P. lefebvrei*, ''beyaz kumi, domalan'' for *T. olbiensis*, and ''siyah - kara kumi'' for *P. juniperi*.

It was observed that *T. boudieri* is the only product that has an economic value as it brings profit. *P. lefebvrei*, *T. olbiensis* and *P. juniperi*, which are used for daily consumption and are more popular amongs to the locals, do not have economic value, as the first one is too small, the second one degrades quickly, and the third one can be rarely found . It was determined that *T. olbiensis* is more attractive when compared to other types, because of its aroma and smell. It was also observed that *T. claveryi* can rarely be found in the area and can be confused with *T. boudieri* by the local people [21]. The most common and well known types include *T. boudieri*, *P. lefebvrei* and *T. olbiensis*, whereas *T. claveryi* and *P. juniperi*, which are now well-known and are rarely found in small areas.

The Environmental Parameters of the Truffle Habitat

The environmental parameters from the studied area, where the Terfezia and Picoa species grow naturally, in the Elazığ-Malatya Province, included the light strength, heat, humidity, air flow, and air velocity. The observed values varied between 17.7 klux and 303.9 klux, 7.8ºC and 24.3ºC, 11.9% and 43.2%, the 3702.6 ft3/min and 8941.6 ft3/min, and 3.6 km/h and 16.9 km/h respectively (Table 1). These values were understood to be different or sometimes similar based on the altitude, geographical location, the time period of measurement and the season (Table 1).

The Soil Characteristics of the Truffle Growth Area

The physical and chemical characteristics of the soil samples from the locations, where different truffle types grow (*T. boudieri*, *T. claveryi*, *T. olbiensis*, *P. lefebvrei* ve *P. juniperi*) are shown in Table 2. The characteristics of the soil samples collected from where the truffles grow were analysed and the amounts of sand, clay, silt, silt-clay, sandy clay, sandy-loam, clay-loam, loam-sand, and sandy-clay-loam in the soil, the pH level, total amount of lime, active lime, salt, organic material, nitrogen, and of various elements were recorded. The recorded amounts, that can be seen in Table 2, indicate that the soil characteristics can vary based on the geographical location, the area where the species were collected from, the altitude, and biotic and abiotic factors (Table 2).

DISCUSSION

It has been indicated earlier that the mycorrhizal structures between the truffle and the host plant can be affected by biotic and abiotic causes that include rainy seasons, amount of precipitation, dryness, climatic conditions, humidity, salination, types of the soil [6-8,10,22-28]. The widespread growth of wild truffle species in different regions are thought to be due to the apropriate ecology, habitat, soil types, host plant, and environmental and climatic conditions as stated by previously mentioned reports.

Most of the Asian-Mediterranean regions, where desert truffle populations can grow, reflect similar climatic attributes: these are inland steppe areas which are characterized by semiarid to arid continental conditions with dry summers and wet winters. The annual precipitation has been recorded to be in between 300 and 600 mm in the relatively wet semiarid areas, and between 50 and 250 mm in the arid areas. Rainfall is often erratic and droughts are common [29]. Truffles mostly prefer areas which have cool winters, damp and warm springs, and hot summers. Other climatic factors that affect truffle production, include day length, amount of sunshine, level of humidity, vapor pressure deficits and evaporation [11]. It was determined that the environmental parameters can be similar or can change based on the geographical location, the area where the species were collected from, the altitude, the time period of measurement and the season [see Table 1, 6-8, 10-11, 30-33]. Our research has shown that in our study area, where *Terfezia* and *Picoa* species grow naturally, the light strength, the heat, humidity, air flow and the air velocity match the climatic requirements mentioned above, which is normal for the region when spring is concerned (see Table 1).

Table 1. Environmental parameters of arid-semi arid (desert) truffles from Eastern Turkey.

Truffle types	Locality	Environmental parameters				
		Illuminance (klüx)	Temperature (°C)	Humidity (%)	Air velocity (CFM, ft³/min)	Air flow (km/h)
1, 4	Kale - Malatya	59.6±9.9 hıi	16.8±0.8 defghıij	24.1±1.0 efghıi	5323.2±503.2 abcd	8.7±0.8 fghıi
1, 3, 4	Kıyıcak, Kale - Malatya	28.5±3.5 bcd	16.9±0.1 defghıij	19.9±1.1 def	4224.8±411.9 ab	6.9±0.6 abcdefghı
1, 4	Kapıkaya, Centre - Malatya	25.5±0.9 bc	7.8±0.1[a]	43.2±0.9 n	5384.0±286.9 abcd	8.7±0.6 efghıi
1, 4	Çolaklı, Centre - Malatya	26.9±0.9 bc	7.8±0.4[a]	42.5±0.4 n	4427.8±273.5 abc	7.2±0.5 bcdefghıi
1,4	Yeniköy, Centre - Malatya	26.2±1.6 bc	12.9±0.8[bc]	40.2±2.1 mn	8620.0±1355.5 ghı	5.3±1.3 abcdefg
1, 3, 4, 5	Meydancık, Battalgazi - Malatya	24.8±0.9 abc	11.1±0.6[b]	41.9±1.9 n	4799.2±699.1 abcd	7.8±1.2 cdefghıi
1, 3, 4	Yarımcahan, Battalgazi - Malatya	29.1±1.4 bcde	11.8±0.2 b	40.0±1.0 mn	5169.6±532.2 abcd	8.5±0.9 efghıi
1, 3, 4	Çolakoğlu, Battalgazi - Malatya	41.3±1.3 efg	13.1±0.2 bc	25.6±0.6 lm	3953.0±829.8 ab	5.9±0.6 abcdefg
1, 3, 4	Adagören, Battalgazi - Malatya	40.5±0.7 def	14.5±0.8 cd	34.5±1.1 kl	4580.8±888.9 abcd	7.5±1.5 bcdefghıi
1, 3, 4	Ağılyazı, Battalgazi - Malatya	122.9±9.0 ö	17.4±0.8 fghıij	28.3±2.6 ij	4566.8±418.6 abcd	7.5±0.7 bcdefghıi
1, 3, 4	Kuluşağı, Battalgazi - Malatya	58.3±1.6 hı	16.6±1.4 defghı	22.5±3.9 defghı	4511.4±317.5 abcd	7.4±0.5 bcdefghıi
1, 3, 4	Şişman, Battalgazi - Malatya	48.4±1.9 fgh	17.3±1.3 efghıij	26.6±1.8 hıij	6657.6±332.6 defgh	3.6±0.2 a
1, 4	Gümüşlü, Arguvan - Malatya	53.4±1.9 gh	15.8±0.3 defgh	21.8±0.5 defgh	5254.0±645.1 abcd	7.8±1.8 cdefghıi
1, 4	Morhamam, Arguvan - Malatya	48.9±1.3 fgh	16.7±0.6 defghıi	24.9±1.0 fghıij	8412.0±1694.1 ghı	5.2±0.9 abcdef
1, 4	Karababa, Arguvan - Malatya	68.6±1.9 ıij	14.7±0.2 cde	22.5±0.8 defghı	5653.8±585.6 abcde	7.9±2.8 cdefghıi
1, 4	Topaluşağı, Baskil -Elazığ	19.6±1.1 ab	16.9±0.1 defghıij	42.1±0.6 n	3702.6±554.7 a	16.9±2.7 k
1, 4	Habipuşağı, Baskil - Elazığ	18.5±0.5 ab	17.7±0.2 fghıijk	39.9±0.7 lmn	5422.8±895.9 abcd	8.3±1.2 defghıi
1, 4	Kuşsarayı, Baskil - Elazığ	17.7±0.7 ab	17.8±1.7 ghıijk	35.7±0.8 lm	8082.6±695.1 fghı	13.5±1.1 jk
1, 3, 4, 5	Alangören, Baskil - Elazığ	70.9±4.8 ij	17.2±0.7 efghıij	19.4±1.2 de	8278.8±401.3 fghı	4.4±0.2 abc
1, 3, 4, 5	Deliktaş, Baskil - Elazığ	35.1±1.7 cde	15.3±0.4 cdefg	17.3±0.4 bcd	4394.4±219.7 abc	7.5±0.9 bcdefghıi
1, 2, 3, 4, 5	Gemici, Baskil - Elazığ	91.4±2.9 kl	16.5±0.2 defghı	13.9±1.3 abc	4419.4±609.6 abc	7.9±1.7 cdefghıi
1, 3, 4	Konacık, Baskil - Elazığ	99.6±1.9 lmn	18.9±2.3 ijjk	13.6±0.5 abc	8636.4±1805.4 hı	5.8±1.8 abcdefg
1, 2, 3, 4, 5	Hacımehmetli, Baskil - Elazığ	103.2±5.6 lmn	15.2±0.7 cdef	13.3±1.2 ab	6087.0±466.3 bcdef	9.9±0.7 hıij
1, 2, 3, 4, 5	Çiğdemlik, Baskil - Elazığ	102.7±2.9 lmn	17.2±1.8 efghıij	12.5±0.6 ab	4705.4±819.9 abcd	7.3±0.5 bcdefghıi
1,3, 4,5	Karakaş, İpşir hamlet, Baskil - Elazığ	117.5±9.1 oö	24.2±1.2 n	25.9±2.9 ghıij	8941.6±602.1 ı	4.8±0.4 abcd
1, 4	Kızıluşağı, Baskil - Elazığ	111.1±4.9 noö	24.3±0.9 n	29.0±3.9 ij	3977.8±243.8 ab	6.5±0.4 abcdefgh
1,4	Yalındam, Baskil - Elazığ	95.6±3.1 lm	17.7±1.0 fghıijk	13.6±1.5 ab	5496.2±960.5 abcd	9.6±3.3 hıi
1,4	Situşağı, Baskil - Elazığ	92.2±1.9 kl	16.6±1.8 defghı	11.9±1.6 a	8421.6±1093.2 ghı	10.4±1.9 ıij
1, 3, 4, 5	Söğütdere, Baskil - Elazığ	106.6±6.0 mno	24.2±1.2 mn	26.7±3.2 hıij	5430.6±964.9 abcd	6.9±2.1 abcdefghı
1, 3, 4, 5	İmikuşağı, Baskil - Elazığ	97.4±2.1 lm	20.1±1.4 kl	27.3±2.0 ıij	8051.6±1972.1 fghı	8.0±2.9 defghıi
1, 3, 4, 5	Tabanbükü, Baskil - Elazığ	98.9±5.6 lmn	20.2±0.7 kl	29.7±7.0 jk	4586.2±1901.6 abcd	7.4±2.8 bcdefghıi
1, 3, 4, 5	Altınuşağı, Baskil - Elazığ	303.9±2.9 p	17.9±0.6 hıijk	20.9±1.7 defg	8758.6±1114.4 hı	4.7±0.6 abcd
1, 2, 3, 4, 5	Bilaluşağı, Baskil - Elazığ	302.2±5.3 p	17.6±0.8 fghıijk	20.6±1.4 defg	4252.4±148.2 abc	6.9±0.3 abcdefghı
1,4	Suyatağı, Baskil - Elazığ	107.4±8.4 mno	16.5±0.3 defghı	20.4±1.3 def	6428.8±258.3 cdefg	10.6±0.5 ij
1,4	Höyükköy, Baskil - Elazığ	76.1±3.2 j	16.9±0.5 defghıij	19.0±0.8 cde	5744.2±756.6 abcde	4.1±2.2 ab
1,4	Kumlutarla, Baskil - Elazığ	81.0±5.1 jk	16.7±1.6 defghıi	20.7±2.4 defg	4549.4±384.3 abcd	7.4±0.6 bcdefghıi

Each value is expressed as mean ± SD of five replicates.

Values with different small letters in the same column are significantly different at the level of 0.05 (P<0.05).

Truffle types (1: *T. boudieri* , 2: *T. claveryi*, 3: *T. olbiensis*, 4: *P. lefebvrei*, 5: *P. juniperi*) and locality (Malatya-Elazığ provincial border zone and its vicinity) from Akyüz et al. [13].

The physical and chemical properties of the soil samples from the locations where different truffle species grow are shown in Table 2. Our analyses have shown that the soil has alkaline characteristics and it has lime content. It was observed that the level of organic material and nitrogen was low, so was the level of electirical conductivity. Based on these and other observations, it was understood that truffles prefer to grow in sandy soil that has high amounts of phosphorus, potassium and sodium (Table 2). Previous research have shown that the amount of N, P, and K that exist in the soil can affect the mycorrhizal structure between the truffle and the host plant [8,22,25,34-36]. It was also indicated that many truffle types grow in soil with sandy properties [34,37], but the physical and chemical characteristics of these soils can change based on where the truffle grows, and the biotic and abiotic factors. Researchers have indicated that areas with sandy-clayey or sandy soil, which are rich in terms of organic material, and basins, valleys and plain fields through which riverbeds cross, are most suitable for truffle growth [7]. Low pH is known to cause a reduction in the calcium content of the soil and tehrefore affects the truffles in the wild in a negative way. Organic matter provides the essential nutrients and energy for macrofungi, improving the physical properties of the soil and giving it a spongy structure by linking separate particles in it [11,38].

It has been indicated in earlies studies that the physical and chemical characteristics of the soil can affect the growth of different types (*Terfezia*, *Tirmania*, *Picoa* species) of truffles. It was also mentioned that depending on the type of soil (sandy, clay, silty, loam calcerous etc.), the humidity level (2-6%), pH (5.8-8.5) level, amount of $CaCO_3$ (4-58%), and the amount of organic material (0.44-2.59%) should be at a certain level, and the soils should have a low level of salinity, organic carbon, electrical conductivity and C/N. On the other hand, this can be different for certain truffle species (*Terfezia* spp.) which prefer different soil types (acidic and sandy) and pH level [8,11,26,30,32-34,37,39-43]. All our studies comply with the observations and results of the research mentioned above, and it is especially important that the physical and chemical characteristics of the soils that the truffle types grow can vary (Table 2).

In conclusion, truffle development is closely related to soil characteristics, climatic conditions, and particularly precipitation, which mainly occurs in early spring seasons. Early spring precipitation represents a significant potential for the growth of truffles. Indeed, as stated in the aforementioned studies, the physical and chemical properties of the soil including the pH level, texture, saturation, amount of organic material and lime, clearly affect the growth of truffle types in the concerned region.

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Table 2. Soil characteristic of arid-semi arid (desert) truffles from Eastern Turkey.

Truffle Types	Locality	Soil texture (%)					pH	Lime (%)		Salt (mmhos/cm)	Organic material (%)	Nitrogen (%)	P_2O_5 (ppm)	K_2O (ppm)	Na (ppm)
		Sand	Clay	Silt	Silt + Clay	Soil Types		Total	Active						
1, 4	Kale - Malatya	60.51	15.86	23.63	39.49	Sandy Loam	8.12	1.50	-	0.204	0.412	0.020	22.44	258.69	16.643
1, 3, 4	Kıyıcak, Kale - Malatya	76.74	10.82	12.44	23.26	Sandy Loam	8.12	3.80	-	0.175	0.288	0.014	54.40	132.94	20.597
1, 3, 4	Yarımcahan, Battalgazi - Malatya	60.39	17.97	21.64	39.61	Sandy Loam	7.97	24.90	10.22	0.275	0.350	0.017	90.63	346.32	16.693
1, 3, 4	Çolakoğlu , Battalgazi - Malatya	68.63	16.94	14.43	31.37	Sandy Loam	7.83	11.32	-	0.299	0.474	0.023	44.10	315.95	20.477
1, 3, 4	Ağılyazı, Battalgazi - Malatya	90.47	5.49	4.04	9.53	Sandy	8.18	7.40	-	0.138	0.535	0.026	28.71	212.06	20.072
1, 3, 4	Kuluşağı, Battalgazi - Malatya	43.57	30.51	25.91	56.43	Clay Loam	8.26	26.57	14.6	0.259	0.659	0.032	62.19	279.33	16.791
1, 3, 4	Şişman, Battalgazi - Malatya	91.46	4.49	4.05	8.54	Sandy	8.15	7.41	-	0.098	0.412	0.020	58.16	58.40	16.394
1, 3, 4	Kuşsarayı, Baskil - Elazığ	80.01	7.10	12.90	19.99	Loamy Sand	7.13	11.15	-	0.108	0.914	0.045	26.01	116.31	16.42
1, 3, 4, 5	Alangören, Baskil - Elazığ	79.44	8.76	11.80	20.56	Sandy Loam	7.19	6.76	-	0.222	1.436	*	*	*	*
1, 3, 4, 5	Deliktaş, Baskil - Elazığ	84.58	5.69	9.73	15.42	Loamy Sand	7.42	5.98	-	0.142	0.672	*	*	*	*
1, 2, 3, 4, 5	Gemici, Baskil - Elazığ	74.75	8.17	17.08	25.25	Sandy Loam	7.11	5.24	-	0.196	0.914	0.045	22.87	374.94	16.55
1, 3, 4	Konacık, Baskil - Elazığ	42.59	37.01	20.40	57.41	Clay Loam	7.58	18.45	-	0.185	1.297	*	*	*	*
1, 2, 3, 4, 5	Hacımehmetli, Baskil - Elazığ	86.60	5.69	7.71	13.40	Loamy Sand	7.69	4.48	-	0.120	0.394	*	*	*	*
1, 2, 3, 4, 5	Çiğdemlik, Baskil - Elazığ	81.54	6.71	11.76	18.46	Loamy Sand	7.22	10.47	-	0.177	2.200	*	*	*	*
1, 3, 4, 5	Karakaş, Baskil - Elazığ	43.16	38.43	18.41	56.84	Clay Loam	7.92	35.79	9.63	0.143	0.780	0.039	51.96	308.60	13.16
1, 4	Situşağı, Baskil - Elazığ	53.89	31.58	14.53	46.11	Sandy Clay Loam	7.89	30.39	13.87	0.242	0.597	0.029	96.36	289.02	20.619
1, 3, 4, 5	Söğütdere, Baskil - Elazığ	71.27	8.78	19.95	28.73	Sandy Loam	7.06	12.03	-	0.319	4.840	*	*	*	*
1, 2, 3, 4, 5	Bilaluşağı, Baskil - Elazığ	81.48	7.74	10.78	18.52	Loamy Sand	8.32	15.75	-	0.092	0.741	*	*	*	*

*: not analysis, -: not determined.

Truffle types (1: *T. boudieri*, 2: *T. claveryi*, 3: *T. olbiensis*, 4: *P. lefebvrei*, 5: *P. juniperi*) and locality (Malatya-Elazığ provincial border zone and its vicinity) from Akyüz et al. [13].

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