Research Article

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MEDITERRANEAN AGRICULTURAL SCIENCES
(2025) 38(1): 43-50
DOI: 10.29136/mediterranean.1466771

Nutrient status of Kırıkhan-Kumlu soils and their relationship with several soil properties

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ARTICLE INFO

Received: April 8, 2024
Received in revised form: March 20, 2025
Accepted: March 21, 2025

***Keywords*:**

Kırıkhan-Kumlu Region
Soil Properties
Fertility status
Relations

ABSTRACT

In this study, it was aimed to determine severalsoil properties and the fertility status of the soils in the Kırıkhan-Kumlu region of Hatay province. For this purpose, a total of 60 soil samples were taken from two depths (0-20 and 20-40 cm) to represent the soils.According to the results of the research; In terms of lime, more than 83.33% of the soils were found to be moderately calcareous to very calcareous and 78.33% of the soils had low to moderate organic matter content;% total nitrogen (N) content of the soils 0.03-1.15 and available phosphorus (P) 0.17-0.38 mg kg^{-1}; exchangeable potassium (K) 47.00-452.00 mg kg^{-1}; exchangeable calcium (Ca) 2534-6282 mg kg^{-1}; exchangeable magnesium (Mg) 737-2429 mg kg^{-1}; available copper (Cu) 0.89-4.68 mg kg^{-1}; iron (Fe) 4.04-13.09 mg kg^{-1}; manganese (Mn) 3.10-21.41 mg kg^{-1} and zinc (Zn) 0.27-1.08 mg kg^{-1}. In the research area, 5.00% of the soils contain very low and 33% very high total N. Very low levels of phosphorus were determined in all of the soils in the study area in terms of phosphorus content. In terms of exchangeable potassium content, 3.33% of the soils were very low, 30.00% were low, 16.67% were medium, 30.00% were high and 20.00% were very high. It was determined that most of the soils were insufficient in respect to available zinc. However, the soils were sufficient in respect to available Ca, Mg, Fe, Mn and Cu. In addition, negative significant relationships were found between the sand contents of the soils and the available P, Ca and Mg contents.

1. Introduction

Soil is an active and necessary natural part of the lithosphere that supports a variety of living species, from invisible creatures to very large trees. Soil contains macro and micro nutrients, which are an important source of nutrition for the biosphere, and helps maintain biodiversity and habitat stability (Küçük and Karaoğlu 2023). In order to be successful in sustainable soil fertility; the amount and balance of plant nutrients in the soil, the protection of soil organic matter, controlled soil tillage, integrated disease-pest and weed control and human factors are important. Appropriate agricultural management should be carried out by taking these factors into consideration. Since some micronutrients, which are absolutely necessary for the survival of plants, are generally not found in the structure of commercial fertilizers widely used in our country's agriculture, they cannot be given to the soil regularly like macronutrients (Çelik and Dengiz 2018).

Increasing the fertility of soils is one of the most important conditions for obtaining the desired rate and quality of products in agriculture. Plant nutrients are one of the most important factors in increasing the productivity of soils in agricultural areas. One of the important aspects for the development of plants are nutrient elements and multiple deficiencies adversely affect yield and quality. In order to obtain the optimum yield from soils, it is essential to have balanced fertilisation and to eliminate the deficiencies of plant nutrients. Therefore, it becomes obligatory to know the plant nutrient element contents of soils (Saraçoğlu et al. 2016). Soil fertility is a crucial factor in the quality of products produced through sustainable agricultural practices. It is a known fact that the imbalance in the proportion of nutrients in the soil where one nutrient is either deficient or excessive compared to others can negatively impact both the uptake and functions of these nutrients in crops, thereby affecting the yield and quality of the plants. In addition, in sustainable agriculture, it is very important to reveal the chemical and physical properties of the soil and to know the relationship between the nutrients in the soil and soil properties in order to provide optimum benefit from fertilisation in the soil (Çimrin and Boysan 2006).

Many studies have been carried out in order to determine the productivity status of similar and different agricultural areas and to find out the possible nutritional problems in advance. In this respect, The fertility status of the Hatay-Arsuz district was investigated by Yalçın and Çimrin (2021). The results of the study revealed that the available P content was low in all of the soils in the district and 47.15% of the soils were low in available K. Yalçın and Çimrin (2019) aimed to determine the nutrient status of common soil groups in Şanlıurfa-Siverek and found that more than half of the soils were deficient in nitrogen (57.90%), phosphorus (65.78%) and zinc (63.16%), while potassium, calcium, magnesium, copper, iron and manganese contents were sufficient. Tekerek and Yıldız (2017), according to the results of their study, which aimed to determine the fertility potential of the agricultural soils of the Arsuz district of Hatay province, it was determined that the phosphorus (P) content of the soils was high, total nitrogen (N) content was low and very low, and there was

no problem in terms of sodium (Na) content. In addition, the results showed that potassium (K) content was very high at 92.30%, calcium (Ca) content was sufficient at 73.07% and Mg content was sufficient. The fertility status of soils in different regions of Turkey has been analysed by many researchers (Okumuş and Yıldız 2017; Bayram et al. 2023). In this context, according to the results of this study, the pH of the soils of the Erzurum and Tortum region was classified as neutral and slightly alkaline, the organic matter content of the soils was high and very slightly saline. Nitrogen deficiency was found in 47%, potassium deficiency in 14%, calcium deficiency in 19%, magnesium deficiency in 22%, iron deficiency in 47%, zinc deficiency in 14% and plant-available manganese deficiency in all soils. It is reported that these soils have adequate properties in terms of plant-available P and Cu. According to the results of another study, plant nutrition problems of the soils of pistachio orchards in Adıyaman were identified and the idea of carrying out studies for farmers' orchards emerged. It was determined that a new and updated fertilisation programme should be established by using organic and chemical fertilisers by taking traditional practices into consideration and irrigation projects should be included by taking climate change into consideration.

In this study, it was aimed to evaluate the fertility status of the soils of the Kırıkhan-Kumlu region of Hatay province by revealing the macro and micronutrient contents of the soils and their relationships with several soil properties.

2. Materials and Methods

2.1. Material

In the study, a total of 60 soil samples were taken at 0-20 and 20-40 cm depths from the soil areas in the Kırıkhan-Kumlu region of Hatay province to represent the region (Figure 1; Table 1). The soil samples were brought to the laboratory on the same day, air-dried in the shade and sieved through a 2 mm sieve to prepare them for analysis (Figure 1).

2.2. Method

The pH values of the soils were determined by using a pH meter in saturation paste and total soluble salt contents were determined using a conductivity meter (Horneck et al. 1989). Lime ($CaCO_3$) content of the soils was measured with Scheibler calcimeter (Nelson 1982). The texture was determined by the hydrometer method (Bouyoucos 1952). Organic matter was determined by the modified Walkley-Black method as (Nelson and Sommers 1982). Cation exchange capacity was determined by the sodium acetate (1N pH 8.2) extraction method (Rhoades 1982). The total nitrogen (N) was determined by the Kjeldahl method (Bremner and Mulvaney 1982); in the analysis of available P, after extraction by the Olsen method (0.5 M NaHCO3; pH 8.5), measurements were made spectrophotometrically according to the Murphy-Riley method and available potassium (K), calcium (Ca) and magnesium (Mg) were extracted with 1 N neutral (pH 7.0) ammonium acetate (CH_3COONH_4) as reported by Anonymous (1992). Soils were extracted with 0.005 M DTPA+0.01 M $CaCI_2$+0.1 M TEA (pH 7.3) according to Lindsay and Norvell (1978) for copper (Cu), iron (Fe), manganese (Mn) and zinc (Zn). Nutrient analyses of the soils were carried out at HMKU central laboratory using an ICP device.

2.3. Statistical method

Correlation and regression analyses between soil properties and nutrients were performed using the SPSS 17 statistical program (Düzgüneş et al. 1987).

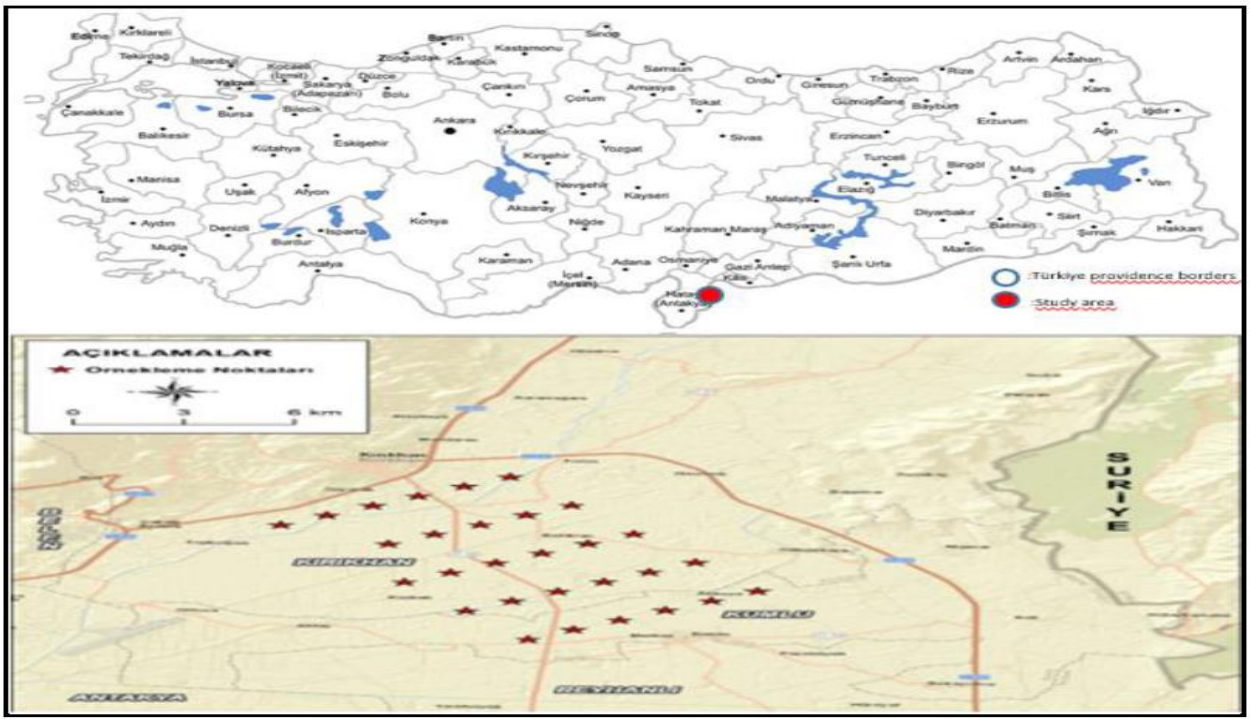

Figure 1. Representation of the soil samples on the map of the Kırıkhan-Kumlu region.

Table 1. Locations where soil samples were taken within Kırıkhan-Kumlu

Soil Number	Sample Place	N/E with GPS Coordinates	Soil Number	Sample Place	N/E with GPS Coordinates
1	Reşatlı	(54.2910 - 40.3829)	16	Özkızılkaya-1	(54.4676 - 40.3183)
2	İçada-1	(54.2162 - 40.3762)	17	Özkızılkaya-2	(54.3927 - 40.3116)
3	İçada-2	(54.1415 - 40.3696)	18	Kumlu-1	(54.3178 - 40.3049)
4	Karadurmuşlu-1	(54.0667 - 40.3629)	19	Kumlu-2	(54.9522 - 40.2931)
5	Karadurmuşlu-2	(53.9920 - 40.3563)	20	Kumlu-3	(54.8536 - 40.2898)
6	Torun	(53.9172 - 40.3496)	21	Akkerpiç-1	(54.7549 - 40.2866)
7	Baldıran-1	(54.5006 - 40.3614)	22	Akkerpiç-2	(54.6562 - 40.2833)
8	Baldıran-2	(54.4258 - 40.3547)	23	Akkuyu	(54.5575 - 40.2800)
9	Muratpaşa-1	(54.3511 - 40.3481)	24	Kumlu-4	(54.4588 - 40.2767)
10	Muratpaşa-2	(54.2763 - 40.3414)	25	Kumlu-5	(54.9716 - 40.2481)
11	Güventaş-1	(54.2016 - 40.3348)	26	Kumlu-6	(54.8717 - 40.2477)
12	Güventaş-2	(54.1268 - 40.3281)	27	Kumlu-7	(54.7718 - 40.2473)
13	Kangallar-1	(54.6923 - 40.3383)	28	Muharrem	(54.6719 - 40.2468)
14	Kangallar-1	(54.6174 - 40.3316)	29	Kırcaoğlu-1	(54.5720 - 40.2464)
15	Kangallar-1	(54.5425 - 40.3250)	30	Kırcaoğlu-2	(54.4721 - 40.2460)

3. Results and Discussion

The results obtained from this research are given under 2 sub-headings as some physical and chemical properties of soils and nutrient contents.

3.1. Physical and chemical properties

pH: The lowest pH content of the study soils was 7.95 and the highest pH content was 8.43. The average pH content of the soil samples at 0-20 cm depth was 8.13, while the average pH content of the samples at 20-40 cm depth was 8.13. According to the classification given by Ülgen and Yurtsever (1995), all of the soil samples in the study area were slightly alkaline (Yalçın 2023).

Salinitiy: The lowest salt content of the soils in the study area was 0.009% and the highest salt content was 0.115%. While the average salt content of the samples at 0-20 cm depth was 0.043%, it was 0.047% in the samples at 20-40 cm depth and 0.046% in the average of both depths. It was determined that the % salt contents of the soil samples were in the salt-free class throughout the entire profile according to the limit values reported by Richards 1954 (Yalçın 2023).

Lime: While the lowest lime content of the soils studied was 0.47%, the highest lime content was determined as 26.59%. While the average lime content of the soil samples at 0-20 cm depth was 13.93%, it was 13.80% at 20-40 cm depth and 13.86% at two depths. According to the classification given by Ülgen and Yurtsever (1995), the lime contents of the soil samples ranged from low calcareous to very high calcareous, but 11.66% of the soils were found to be low calcareous, 5.00% calcareous, 35.00% medium calcareous, 45.00% high calcareous and 3.33% very high calcareous (Yalçın 2023).

Organic Matter: While the lowest organic matter content of the soils was 1.16%, the highest organic matter content was determined as 6.08%. The average organic matter content of the soil samples at 0-20 cm depth was 2.61%, while it was 2.69% in the samples at 20-40 cm depth and 2.60% was found on average at both depths. According to the classification given by Ülgen and Yurtsever (1995), the organic matter of the soil samples ranged from low to high, with 30.00% of the soils having low organic matter, 48.33% having medium organic matter, 15.00% having good organic matter and 6.66% having high organic matter (Yalçın 2023).

Texture: The lowest clay, sand and silt contents of the Kırıkhan-Kumlu soils were 18.88%, 7.12% and 15.28%, while the highest clay, sand and silt contents were 74.16%, 59.84% and 52.72%, respectively. The average amounts of clay, sand and silt in the 0-20 cm depth of the soils were 40.52%, 20.87% and 30.03%, while the average amounts of clay, sand and silt in the 20-40 cm depth samples were 48.88%, 22.34% and 27.18% and the average amounts were 43.31%, 21.61% and 15.28%. The Kırıkhan-Kumlu soils of Hatay province are classified into 6 different texture classes as 65.00% clay (C), 20.00% clay loam (CL), 8.34% silty clay loam (SiCL), 3.34% sandy clay loam (SCL), 1.66% sandy loam (SL) and 1.66% silty clay (SiC) (Yalçın 2023).

3.2. Plant nutrients status

3.2.1. Total Nitrogen (N)

The findings of some nutrient contents of the soils used in the study are given in Table 2. While the lowest total nitrogen content was 0.03%, the highest nitrogen content was 1.15%. The average nitrogen content of the soil samples at 0-20 cm depth was 0.39%, while it was 0.29% in the samples at 20-40 cm depth and 0.34% in both depths. When the total nitrogen contents of the soil samples were classified according to the limit values given by Kovancı (1969), 5.00% of the soils were very low in nitrogen (<0.05), 8.33% were low (0.05-0.09), 25.00% were medium (0.09-0.17), 28.34% were high (0.17-0.32) and 33.33% were very high (>0.32) (Table 2). The fact that there is medium and high levels of organic matter content in many parts of the agricultural soils in the study area is seen as the most important reason for the total nitrogen amounts of the soils being higher than normal. It should not be forgotten that the decomposition of organic matter over time due to the effects of temperature and humidity can explain the high total nitrogen amount in the soil at some points. In a study conducted in a nearby region, Bayram et al. (2023) aimed to determine the fertility status of pistachio orchards in Adıyaman province with soil samples. In their study, the total nitrogen content of the soils ranged between 0.04-0.65% with an average of 0.21%. In their study conducted in the same region,

Table 2. N, P, K, Ca, Mg, Cu, Fe, Mn and Zn contents of soils of Kırıkhan-Kumlu region of Hatay province

Soil Number	Depth	N	P	K	Ca	Mg	Cu	Fe	Mn	Zn
		%				mg kg^{-1}				
1	0-20	0.24	0.24	120	3663	1713	3.35	9.95	5.33	0.55
	20-40	0.20	0.25	123	3561	1685	3.83	13.09	6.21	0.82
2	0-20	0.17	0.28	166	2534	1374	2.01	8.59	19.26	0.57
	20-40	0.10	0.26	152	2705	1360	2.13	9.11	19.99	0.78
3	0-20	0.11	0.24	185	3536	1487	3.11	9.74	15.90	0.71
	20-40	0.07	0.25	177	3107	1480	3.17	10.30	15.31	0.84
4	0-20	0.25	0.25	53	3441	1021	0.89	9.82	8.68	0.51
	20-40	0.14	0.25	48	3460	1040	0.93	10.07	7.84	0.52
5	0-20	0.11	0.35	209	6022	1912	3.23	6.91	3.91	1.08
	20-40	0.05	0.37	202	6086	1917	3.07	6.36	3.10	0.82
6	0-20	0.07	0.35	162	3040	1073	1.68	8.60	14.04	0.97
	20-40	0.04	0.33	171	3015	1024	1.58	7.71	13.51	0.90
7	0-20	0.37	0.29	295	4644	1169	3.12	8.78	19.37	0.71
	20-40	0.28	0.28	272	4743	1166	3.16	8.73	18.93	0.66
8	0-20	0.38	0.25	149	4468	1153	2.83	8.48	9.88	0.90
	20-40	0.30	0.35	159	4452	1198	3.00	8.97	11.80	0.82
9	0-20	0.29	0.31	286	6268	1201	3.97	9.12	4.64	0.82
	20-40	0.18	0.29	278	6282	1225	4.10	9.36	5.07	0.94
10	0-20	0.32	0.27	144	4295	997	2.66	10.97	6.95	0.69
	20-40	0.24	0.31	142	4289	1006	2.36	9.87	6.10	0.59
11	0-20	0.43	0.35	241	4504	1648	3.94	11.23	13.36	0.36
	20-40	0.36	0.37	233	4526	1681	4.04	11.51	13.76	0.39
12	0-20	0.11	0.35	362	4991	1309	3.78	8.02	11.20	0.40
	20-40	0.06	0.29	363	4646	1402	3.68	7.81	9.42	0.40
13	0-20	0.18	0.28	329	5157	1578	3.68	6.83	15.20	0.79
	20-40	0.10	0.33	310	5151	1596	3.91	7.57	12.89	0.55
14	0-20	0.22	0.30	272	5172	1704	3.36	9.23	7.06	0.77
	20-40	0.14	0.34	277	5172	1751	4.68	12.62	9.96	1.03
15	0-20	0.47	0.27	260	5119	2429	2.99	7.08	6.32	0.65
	20-40	0.38	0.30	249	4655	2363	3.13	7.30	5.94	0.77
16	0-20	0.16	0.36	375	4556	1654	2.60	5.24	4.66	0.47
	20-40	0.12	0.38	392	4831	1643	2.72	5.82	5.66	0.69
17	0-20	0.18	0.31	306	5036	2118	2.77	6.49	7.22	0.36
	20-40	0.13	0.34	311	5063	2118	2.85	7.20	7.09	0.34
18	0-20	0.12	0.35	190	4669	973	2.50	6.07	10.03	0.34
	20-40	0.07	0.32	197	4652	974	2.55	7.44	11.14	0.38
19	0-20	0.03	0.36	208	4711	1070	2.47	4.71	11.53	0.71
	20-40	0.09	0.33	199	4720	964	2.43	4.82	9.35	0.69
20	0-20	0.15	0.22	166	3769	1780	1.96	4.04	9.37	0.81
	20-40	0.10	0.28	159	3873	1735	1.86	4.21	8.60	0.60
21	0-20	0.19	0.20	355	5063	1927	2.91	8.31	8.92	0.62
	20-40	0.14	0.19	367	4996	1935	2.79	8.00	7.18	0.51
22	0-20	1.05	0.27	446	5118	1755	3.65	9.27	21.41	0.51
	20-40	0.82	0.24	412	5115	1773	3.36	8.60	12.69	0.45
23	0-20	1.15	0.20	302	4036	2412	3.73	7.99	13.50	0.54
	20-40	0.95	0.19	288	4080	2421	3.59	7.56	10.77	0.48
24	0-20	1.14	0.21	290	4400	1141	2.84	5.38	19.03	0.57
	20-40	0.84	0.24	288	4346	1486	2.69	4.87	19.61	0.61
25	0-20	0.42	0.26	245	5400	1350	4.48	9.57	9.22	0.43
	20-40	0.28	0.25	263	5486	1404	4.58	11.24	9.67	0.50
26	0-20	1.02	0.28	217	4469	1954	3.55	9.15	15.17	0.54
	20-40	0.71	0.23	183	4487	2039	3.76	9.41	11.91	0.35
27	0-20	1.06	0.18	287	4249	2016	3.75	9.51	13.75	0.45
	20-40	0.81	0.17	243	4139	2033	3.87	9.30	10.99	0.41
28	0-20	0.48	0.23	441	4035	737	2.00	6.28	14.09	0.50
	20-40	0.31	0.22	452	3877	783	1.94	4.98	12.56	0.49
29	0-20	0.42	0.20	240	4248	1276	2.38	6.59	11.90	0.27
	20-40	0.30	0.23	255	4265	1278	2.54	6.29	13.96	0.27

Table 2. (Continued).

Soil Number	Depth	N	P	K	Ca	Mg	Cu	Fe	Mn	Zn
		%				mg kg^{-1}				
30	0-20	0.39	0.21	328	4795	2299	2.82	5.39	6.08	0.57
	20-40	0.24	0.21	318	4590	2355	3.14	5.56	6.75	0.50
Min		**0.03**	**0.17**	**48.00**	**2534**	**737**	**0.89**	**4.04**	**3.10**	**0.27**
Max		**1.15**	**0.38**	**452.00**	**6282**	**2429**	**4.68**	**13.09**	**21.41**	**1.08**
Ave.	**0-20**	**0.39**	**0.27**	**254.31**	**4513**	**1541**	**2.97**	**7.91**	**11.23**	**0.61**
Ave.	**20-40**	**0.29**	**0.28**	**249.42**	**4479**	**1561**	**3.05**	**8.19**	**10.59**	**0.60**
	Ave.	**0.34**	**0.28**	**251.87**	**4496**	**1551**	**3.01**	**8.05**	**10.91**	**0.61**

Yalçın et al. (2018) found similar results in terms of total nitrogen content of the meadow-pasture soils of the Kırıkhan-Reyhanlı region of Hatay province between 0.01-1.34% with an average of 0.24%. In a study conducted in a nearby region, Oya and Çimrin (2023) analysed the nutritional status of orange orchards in the Mersin-Tarsuz district and found that nearly 65% of the soils contained sufficient nitrogen in terms of total nitrogen.

3.2.2. Available Phosphorus (P)

The lowest and highest available phosphorus contents of the soils of the Kırıkhan-Kumlu region were 0.17 and 0.38 mg kg^{-1}, respectively. While the average phosphorus content of the soils at 0-20 cm depth was 0.27 mg kg^{-1}, it was 0.28 mg kg^{-1} in the samples at 20-40 cm depth. When the soils sampled were evaluated according to the limit values reported by Ülgen and Yurtsever (1995), very low (<3 mg kg^{-1}) phosphorus content was found in all soils (Table 2). The high lime content of the agricultural soils in the study area reduces the availability of some important nutrients such as phosphorus, which affects the productivity of these soils. Therefore, it can be understood why the available phosphorus content of the region's soils is at very low levels. According to Bayram et al (2023), high lime and pH contents of soils limit the usefulness of some nutrients such as phosphorus, zinc and iron. This gives us information about the P content of the soils of the study area. Ete Aydemir et al. (2021), in their study aiming to determine some physical and chemical properties and fertility status of the soils where hazelnut cultivation is practiced, determined that the soils were inadequate in terms of available phosphorus content above 90% and presented parallel results. Bayram et al. (2023), who carried out a similar study in a neighbouring region, showed similar results in terms of phosphorus content of the soils by determining nearly 93% inadequacy.

3.2.3. Available Potassium (K)

The lowest exchangeable potassium content of the whole soil was 48.00 mg kg^{-1} and the highest was 452.00 mg kg^{-1}. The average exchangeable potassium content of the soil samples at 0-20 cm depth was 254.31 mg kg^{-1}, while it was 249.42 mg kg^{-1} at 20-40 cm depth and 251.87 mg kg^{-1} at both depths. When the exchangeable potassium contents of the samples were classified according to the limit values given by Pizer (1967), 3.33% of the soils were very low (>100 mg kg^{-1}), 30.00% were low (100-200 mg kg^{-1}), 16.67% were medium (200-250 mg kg^{-1}), 30.00% were high (250-320 mg kg^{-1}) and 20.00% were very high (>320 mg kg^{-1}) (Table 2). In a study conducted in a nearby region, Kalkancı et al. (2023) aimed to determine some fertility characteristics of the soils where pistachio was grown in different districts of Gaziantep province and found that almost 90% of the soils were adequate in terms of exchangeable potassium content. Similarly, Ordu and Aşık (2021) reported that nearly 92% of the soils were at a sufficient level in terms of exchangeable potassium content in their study aiming to determine the fertility status of the soils where intensive corn cultivation was carried out in the Karacabey district of Bursa province.

3.2.4. Available Calcium (Ca)

The lowest calcium content of the soils was 2534.00 mg kg^{-1} and the highest was 6282.00 mg kg^{-1}. The average calcium content of the soil samples at 0-20 cm depth was 4513.00 mg kg^{-1} and 4479.00 mg kg^{-1} at 20-40 cm depth and the average of both depths was 4496.00 mg kg^{-1}. The calcium content of the soil samples was classified according to Summer and Miller (1996) and it was determined that all of the calcium content of the soils contained high levels of calcium (2500-10000 mg kg^{-1}) (Table 2). In a study conducted in the same region, Gökçeoğlu and Çimrin (2022) aimed to determine the nutritional status of olive (Olea europaea L.) trees in the Altınözü district of Hatay with leaf and soil samples. In their study, the calcium contents of the soils ranged between 3800-6872 mg kg^{-1} with an average of 5321 mg kg^{-1} and similar results were obtained. Bilir et al. (2023) reported that all of the soils were high in terms of Ca content in the study in which they aimed to determine some properties and nutrient levels of agricultural soils of the Silopi district of Şırnak province.

3.2.5. Available Magnesium (Mg)

The lowest magnesium content of the soils was 737.00 mg kg^{-1} and the highest was 2429.00 mg kg^{-1}. The average calcium content of the soil samples at 0-20 cm depth was 1541.00 mg kg^{-1} and 1561.00 mg kg^{-1} at 20-40 cm depth and 1551.00 mg kg^{-1} at both depths. When the magnesium content of the soil samples was classified according to Sumner and Miller (1996), it was determined that 50.00% of the magnesium content of the soils was high (480-1500 mg kg^{-1}) and 50.00% was very high (>1500 mg kg^{-1}) (Table 2). According to Abacı Bayar and Boyacı (2021); high amounts of elements such as K and Ca in the soil solution can cause deficiency by reducing Mg uptake. Çelik and Urhan (2020), in their study aiming to evaluate the nutritional status of cherry orchards in Keles region by soil, leaf and fruit analysis, similarly reported that the Mg content of the soils was above the limit values (>480 mg kg^{-1}) in terms of magnesium content. Abacı Bayar and Boyacı (2021) investigated the nutritional status of orchards in Kırşehir and found similar results by determining the Mg content of soils around 56%.

3.2.6. Available Copper (Cu)

The lowest copper content of the soils was 0.89 mg kg^{-1} and the highest copper content was 4.68 mg kg^{-1}. The average copper content of the soil samples at 0-20 cm depth was 2.97 mg kg^{-1}, while it was 3.05 mg kg^{-1} in the samples at 20-40 cm depth and 3.01 mg kg^{-1} was found on average at both depths. When the copper content of the soil samples was compared with the limit

values reported by Lindsay and Norvell (1978), it was observed that all of the soils were at a sufficient level (>0.2 mg kg^{-1}) in terms of available copper content (Table 2). Similarly, Özsayar and Çimrin (2022) reported that all of the soils were adequate in terms of available copper content in their study aiming to determine the nutritional status of olive trees in the Hassa district of Hatay province with leaf and soil samples. Similarly, Bayram and Büyük (2021) determined that the Cu content of the soils was sufficient in their study to determine the nutrient levels in fruit trees without tillage and fertilisation.

3.2.7. Available Iron (Fe)

The lowest available iron content of the soils of the study area was 4.04 mg kg^{-1} and the highest iron content was 13.09 mg kg^{-1}. The average iron content of the samples at 0-20 cm depth was 7.91 mg kg^{-1}, while it was 8.19 mg kg^{-1} in the samples at 20-40 cm depth and the average of both depths was 8.05 mg kg^{-1}. When the available iron contents of the soils were classified according to the limit values of Lindsay and Norwell (1978), it was observed that there was no iron deficiency in the soils and 3.33% of the samples were found to be sufficient (2.5-4.5 mg kg^{-1}) and 96.67% of the samples were found to be excessive in terms of available iron (>4.5 mg kg^{-1}) (Table 2). Ete Aydemir et al. (2021) in their study aiming to determine some physical and chemical properties and fertility status of hazelnut cultivated soils, determined that the soils were more than 95% adequate in terms of available Fe content and presented parallel results. In a study conducted in a nearby region, Oya and Çimrin (2023) aimed to determine the nutritional status of orange orchards in the Tarsus district of Mersin province with leaf and soil samples.

3.2.8. Available Manganese (Mn)

The lowest available manganese content of the study area was 3.10 mg kg^{-1} and the highest available manganese content was 21.41 mg kg^{-1}. While the average manganese content of the samples at 0-20 cm depth was 11.23 mg kg^{-1}, it was 10.59 mg kg^{-1} in the samples at 20-40 cm depth and 10.91 mg kg^{-1} was found as the average of both depths. When the available manganese contents of all the soils of the study area were classified according to the limit values determined by Follet and Lindsay (1978), all of them were found to be sufficient (>1.00 mg kg^{-1}) (Table 2). Sohrabi and Yildiz (2023) in their study aiming to determine the nutritional status of date palm (Phoenix dactylifera L.) plants widely cultivated in the Ahvaz/Iran region by soil and plant analyses, found that the soils were adequate in terms of manganese contents and the values of available manganese were determined as 10.80-18.80 mg kg^{-1}. Bilir et al. (2023) reported that all of the soils were adequate in terms of Mn content in the study in which they aimed to determine some properties and nutrient levels of agricultural soils of the Silopi district of Şırnak province.

3.2.9. Available Zinc (Zn)

The lowest available zinc content of the soils of the Kırıkhan-Kumlu region of Hatay province was 0.27 mg kg^{-1} and the highest was 1.08 mg kg^{-1}. The average zinc content of the soils at 0-20 cm depth was 0.61 mg kg^{-1},while the average zinc content of the samples at 20-40 cm depth was 0.60 mg kg^{-1}. According to Viets and Lindsay (1973), 68.34% of the soils of Kırıkhan-Kumlu region of Hatay province were deficient (<0.7 mg kg^{-1}), 28.34% were critical (0.7-1 mg kg^{-1}) and 3.33% were adequate (>1 mg kg^{-1}) (Table 2). Atmaca and Nalbant (2020) determined the available Zn contents of soils between 0.10-1.76 mg kg^{-1} in the study in which they determined the agricultural characteristics of soils formed in different topographies in the Şebinkarahisar district of Giresun province and presented similar results. Bayram et al. (2023) reported that the soils were insufficient in terms of Zn content in the study in which they aimed to determine the fertility status of pistachio soils in the Adıyaman province.

3.3. The relationship between some soil properties and available nutrients

The relationships between some physical and chemical properties of the investigated soil properties and macro and micronutrients are given in Table 3. As can be seen from the table, a positive significant relationship was determined between total nitrogen content of soils and clay r: 0.29* and CEC r: 0.26* contents. Similar results were obtained in a study conducted by Özsayar and Çimrin (2022) in the same region to determine the nutritional status of olive trees in the Hassa district of Hatay province. There was a negative significant relationship between available phosphorus content of soils and sand content r: -0.30*, while a negative significant relationship was found between available phosphorus and organic matter content r: 0.33*. Abacı-Bayar et al. (2020) reported similar results in their study aiming to investigate some properties of the soils formed in the Seyfe Lake wetland in the Middle Kızılırmak section. Negative significant relationships were determined between the exchangeable potassium content of soils and sand r: -0.41** and silt r: -0.36** contents, while positive significant relationships were determined between exchangeable potassium and clay r: 0.55**, lime r: 0.33* and CEC r: 0.46** contents. Çelik and Batmaz (2020) aimed to determine the nutritional status of kiwifruit orchards in the Orhangazi region and found similar results. In addition, while negative significant relationships were determined between exchangeable calcium and pH r: -0.29* and sand r: -0.56** contents of soils, positive significant relationships were determined between exchangeable calcium and salt r: 0.32*) clay r: 0.59**, lime r: 0.35**, organic matter r: 0.41** and CEC r: 0.69** contents. Karadeniz (2023) determined similar results in his study which aimed to determine some physical and chemical properties of soils grown in the Kumru region. Negative significant relationships were determined between exchangeable magnesium and sand r: -0.55** and silt r: -0.45** contents, while positive significant relationships were determined between exchangeable magnesium and salt r: 0.42**, clay r: 0.72**, organic matter r: 0.29* and CEC r: 0.72** contents. In a study conducted in a different region, Reis and Dindaroğlu (2023) determined similar results in their study to determine some properties of soils and the relationships between them in the Karasu Stream karst precipitation basin. While a negative significant relationship was determined between available copper and pH r: -0.31* and sand r: -0.76** contents of soils, positive significant relationships were determined between available copper and clay r: 0.71**, organic matter r: 0.37** and CEC r: 0.68** contents. Similarly, Çelik and Urhan (2020) found similar results in their study aiming to determine the nutritional status of cherry orchards in the Keles region. Negative significant relationships were determined between available Mn and salt r: -0.26* and CEC r: -0.31* contents of soils. In a study conducted in the same region, Yalçın and Çimrin (2021) aimed to determine the nutrient status of the soils of the Arsuz district of Hatay province and found similar results. While a negative relationship was determined between the available Zn and lime

Table 3. Correlation coefficients (r) between nutrients and some soil properties of the soils of the Kırıkhan-Kumlu region of Hatay province

	pH	Salt (%)	Clay (%)	Sand (%)	Silt (%)	Lime (%)	OM (%)	CEC (me 100 gr^{-1})	N (%)	P (mg kg^{-1})	K (mg kg^{-1})	Ca (mg kg^{-1})	Mg (mg kg^{-1})	Cu (mg kg^{-1})	Fe (mg kg^{-1})	Mn (mg kg^{-1})
Salt (%)	-0.29*															
Clay (%)	-0.08	0.28*														
Sand (%)	0.21	-0.32*	-0.80**													
Silt (%)	-0.16	-0.04	-0.58**	-0.03												
Lime (%)	-0.19	0.39**	0.24	-0.24	-0.08											
OM (%)	-0.17	0.03	0.34**	-0.32*	-0.13	-0.35**										
CEC (me 100 gr^{-1})	-0.22	0.36**	0.85**	-0.75**	-0.40**	0.14	0.52**									
N (%)	0.06	0.07	0.29*	-0.19	-0.23	0.18	-0.15	0.26*								
P (mg kg^{-1})	0.02	0.10	-0.07	-0.02	0.13	0.04	0.33*	-0.09	-0.52**							
K (mg kg^{-1})	-0.23	0.04	0.55**	-0.41**	-0.36**	0.33*	0.09	0.46**	0.27*	-0.10						
Ca (mg kg^{-1})	-0.29*	0.32*	0.59**	-0.56**	-0.22	0.35**	0.41**	0.69**	0.01	0.27*	0.45**					
Mg (mg kg^{-1})	0.01	0.42**	0.72**	-0.55**	-0.45**	0.17	0.29*	0.72**	0.34**	-0.24	0.22	0.21				
Cu (mg kg^{-1})	-0.31*	0.23	0.71**	-0.76**	-0.16	0.15	0.37**	0.68**	0.29*	0.02	0.33**	0.57**	0.41**			
Fe (mg kg^{-1})	0.05	-0.16	0.12	-0.02	-0.18	-0.22	0.16	-0.04	0.06	-0.01	-0.31*	-0.08	-0.03	0.44**		
Mn (mg kg^{-1})	0.06	-0.26*	-0.24	0.11	0.25	-0.10	-0.20	-0.31*	0.39**	-0.20	0.11	-0.42**	-0.25	-0.04	0.05	
Zn (mg kg^{-1})	-0.21	0.15	-0.16	0.08	0.16	-0.40**	0.45**	-0.02	-0.31*	0.27*	-0.27*	0.04	-0.10	-0.02	0.12	-0.12

content r: -0.40**, a positive relationship was determined between the available Zn and organic matter content r: 0.45**. In a study conducted in a different region, Abacı-Bayar et al. (2020) reported similar results in a study aiming to investigate some properties of soils formed in the Seyfe Lake wetland in the Middle Kızılırmak section (Table 3).

4. Conclusion

It can be said that the soils of the Kırıkhan-Kumlu region have six different texture classes and nearly 85% of the soils have clay and clay loam content as texture class. In terms of soil reaction, the soils in the study area are generally slightly alkaline reaction suitable for plant growth, and in terms of salinity, it is seen that there is no problem in terms of salt since the soils are classified as non-saline. Significant positive correlations were found between total nitrogen content and K, Mg, Cu and Mn content; between available phosphorus and Ca and Zn content; between exchangeable potassium content and exchangeable Ca and Cu content; between exchangeable Ca and exchangeable Cu content; between exchangeable Mg and exchangeable Cu content and between exchangeable Cu and exchangeable Fe content. Significant negative relationships were found between total nitrogen content and available phosphorus and Zn content; between exchangeable potassium and available Fe and Zn content; between exchangeable Ca content and available Mn content. The high lime content of the soils reduces the availability of some important nutrients such as phosphorus, which affect productivity in these soils. As a result of the inadequacy of the producers in fertilisation and the consumption of the nutrients in the soil, product yield decreases over the years. In addition to the inadequacy of fertilisation, the inadequacy of practices that protect the fertility of the soil such as reduced tillage, fallow and crop rotation reduces the fertility of the soils of the province. As a result, when we look at the fertility status of the soils of the Kırıkhan-Kumlu region of Hatay province; although it has enough values in terms of total nitrogen, it is revealed that the soils should be supported with fertilisation in terms of available phosphorus and zinc. However, this does not mean that the soils of the region need nitrogen fertilisation as much as phosphorus and zinc fertilisation. In accordance with the plant pattern grown in this region, nitrogen, phosphorus and zinc fertilisation should be done appropriately.

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