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Determination of useful boron content of the soils of Kırıkhan-Kumlu region of Hatay province and their relationship with some soil properties

Mehmet YALÇIN

Hatay Mustafa Kemal University, Faculty of Agriculture, Soil Science and Plant Nutrition, Hatay, Türkiye

Corresponding author: myalcin@mku.edu.tr

Abstract

In this study, it was aimed to determine the useful boron content of the soils of Kırıkhan-Kumlu region of Hatay province and its relationships with some physical and chemical properties. For this purpose, a total of 60 soil samples were taken from 0-20 and 20-40 cm depths and from 30 different points to represent the study area. The pH, total salt, composition, cation exchange capacity (CEC), lime, organic matter and useful boron contents of the soils were determined. According to the results of the research; pH contents of the soils were 7.95-8.43; total salt contents 0.009-0.115 %; clay contents 18.88-74.16 %; sand contents 7.12-59.84 %; silt contents 15.28-52.72 %; lime contents 0.47-26.59 %; organic matter contents 1.16-6.08 %; CEC contents 22.26-72.83 me/100 g and useful boron contents 0.10-1.25 mg/kg. In terms of useful boron content of Kırıkhan-Kumlu soils of Hatay province, it was determined that 50.00 % of them were very low, 40.00 % were low and 10.00 % were sufficient at 0-20 cm depth and 50.00 % of them were very low, 43.34 % were low and 6.66 % were sufficient at 20-40 cm depth. While a positive significant relationship was determined between useful boron and salt, clay, lime and CEC contents of soils, a negative significant relationship was determined between useful boron and sand content. Positive significant relationships were determined between salt and clay, lime and CEC contents of the soils, while negative significant relationships were determined between salt and pH and sand contents. Positive significant relationships were determined between clay and organic matter and CEC contents of the study area soils, while negative significant relationships were determined between clay and sand and silt contents. Significant negative relationships were determined between sand and organic matter and CEC contents of the soils. At the same time, while negative significant relationships were determined between silt and CEC and lime and organic matter contents of the soils, positive significant relationships were determined between organic matter and CEC. As a result, it was seen that the useful boron content of the soils in the study area was determined at low and very low levels above 92 % in all soils of the study area and it was seen that the useful boron content of the soils was insufficient and therefore boron fertilization should be done.

Key Words: Kırıkhan-Kumlu, Available Boron, Physical and Chemical Properties

Introduction

Soil is a dynamic entity where plants accumulate the nutrients they need to continue their vital cycles, microorganisms can provide their activities, reduce the negativities of harmful toxicities that prevent the continuity of the life of living life and end their transformation by filtering pollutants harmful to the natural environment (Yeter and Yalçın 2020). In addition to having the desired level of plant nutrients, it is very important for production and productivity that the biological, physical and chemical properties of soils are suitable for agriculture. In field and horticultural agriculture, plants remove a significant amount of nutrients from soils through their roots during their developmental periods, and improper soil management such as unbalanced fertilization reduces the productivity of soils over time. In order to ensure the continuity of the decreasing productivity of agricultural areas, it is of great importance to periodically determine the nutrient

needs and adequacy of plants by soil analysis and to measure the nutrient needs and adequacy of plants (Karaduman and Çimrin 2016).

It has been determined that boron (B), which has a very important place in terms of plant nutrition in agriculture, has antogonistic relationships with nitrogen (N), calcium (Ca), magnesium (Mg), iron (Fe) and manganese (Mn) and synergistic relationships with phosphorus (P), potassium (K), zinc (Zn) and copper (Cu) (Gezgin and Hamurcu, 2006). The most important feature that distinguishes boron from other elements is that its sufficient and toxic amounts in soil are very close to each other. In addition, the proper utilization of B element in the soil for plants is affected by factors such as soil pH, organic matter, moisture, temperature and clay mineralogy (Goldberg 1997). One of the most important reasons for the different sensitivity to B content among species as well as among plants is that plants are physiologically affected differently by B (Demiral et al. 2010).

According to the parent material of the soils, the uptake of B in the soil differs in terms of plants according to the way it is found in the soil and its retention by the soil. Although light textured soils, acidic or alkaline soil pH, low organic matter and high lime content are desired, drought and too much rainfall are the reasons that reduce the utilization of B by plants (Gürel et al. 2010).

Many similar studies have been conducted on the boron status of agricultural soils. In a study conducted in the same region, Açıkel and Yalçın (2021) aimed to determine the useful boron content of the soils of Reyhanlı-Kumlu region of Hatay province and its relations with some physical and chemical properties. According to the results of the study; pH contents of the soils were found between 6.86-8.44 %; total salt contents between 0.007-0.070 %; clay contents between 15.84-76.56 %; sand contents between 0.72-51.44 %; silt contents between 16.72-47.28 %; lime contents between 2.71-64.23 %; organic matter contents between 0.40-2.89 %;CEC contents between 26.43-91.13 me/100 g and useful boron contents between 0.07-1.76 mg/kg. In terms of useful boron content of Reyhanlı-Kumlu soils of Hatay province, 22.50 % of them were very low, 50.00 % of them were low and 27.50 % of them were sufficient at 0-20 cm depth and 37.50 % of them were very low, 40.00 % of them were low and 22.50 % of them were sufficient at 20-40 cm depth. As a result, in the study area soils, the useful boron content of the soils was determined as low and very low level over 77 % in all study area soils and it was seen that the useful boron content of the soils was insufficient and therefore boron fertilization should be done. In a study conducted in the same region, Yalçın and Çimrin (2017) aimed to determine the boron content of the meadow-pasture soils in the Kırıkhan-Reyhanlı region of Hatay province and to determine their relationship with some soil properties. According to the results of their study; pH contents of the soils were found between 6.85-8.16; salt content 0.01-0.21 %; clay contents 4.60-65.30 %; sand contents 8.70-85.40 %; silt contents 8.00-58.00 %; lime contents 3.40-53.95 %; organic matter contents 0.29-5.52 % and available boron contents 0.00-1.31 ppm. At the same time, in terms of boron content of meadow pasture soils, 70 % of them were found to be very low, 27.50 % were found to be low and 2.50 % were found to be sufficient at 0-20 cm depth, while 72.50 % were found to be very low, 17.50 % were found to be low and 10 % were found to be sufficient at 20-40 cm depth. In addition, they determined a negative significant relationship between boron and sand contents of soils, while they determined positive significant relationships between boron and salt, clay, silt and lime contents. In another study, Çimrin et al. (2019) aimed to determine the boron status of olive orchard soils in Nizip district of Gaziantep province. According to the results of the study; pH contents of the soils were found between 7.93-8.44; salt contents between 0.010-0.043 %; clay contents between 33.04-61.04 %; sand contents between 11.68-35.36 %; silt contents between 18.32-50.32 %; lime contents between 8.11-93.28 % and available boron contents between 0.06-1.18 ppm. In terms of boron content of the garden soils, it was determined that 85.00 % was very low, 10.00 % was low and 5.00 % was sufficient at 0-30 cm depth, 95.00 % was very low and 5.00 % was low at 30-60 cm depth.

In this study, it was aimed to determine the useful B levels of the soils of Kırıkhan-Kumlu region of Hatay province and their relationships with some soil properties and to shed light on the farmers of the region in the future studies for agricultural purposes.

Materıals and methods

Material

A total of 60 soil samples taken from 30 different points (Figure 1; Table 1) and 2 different depths (0-20 and 20-40 cm) in Kırıkhan-Kumlu region of Hatay province were dried in soil drying pans in the laboratory in order to determine useful B, basic chemical and physical properties of the soils.

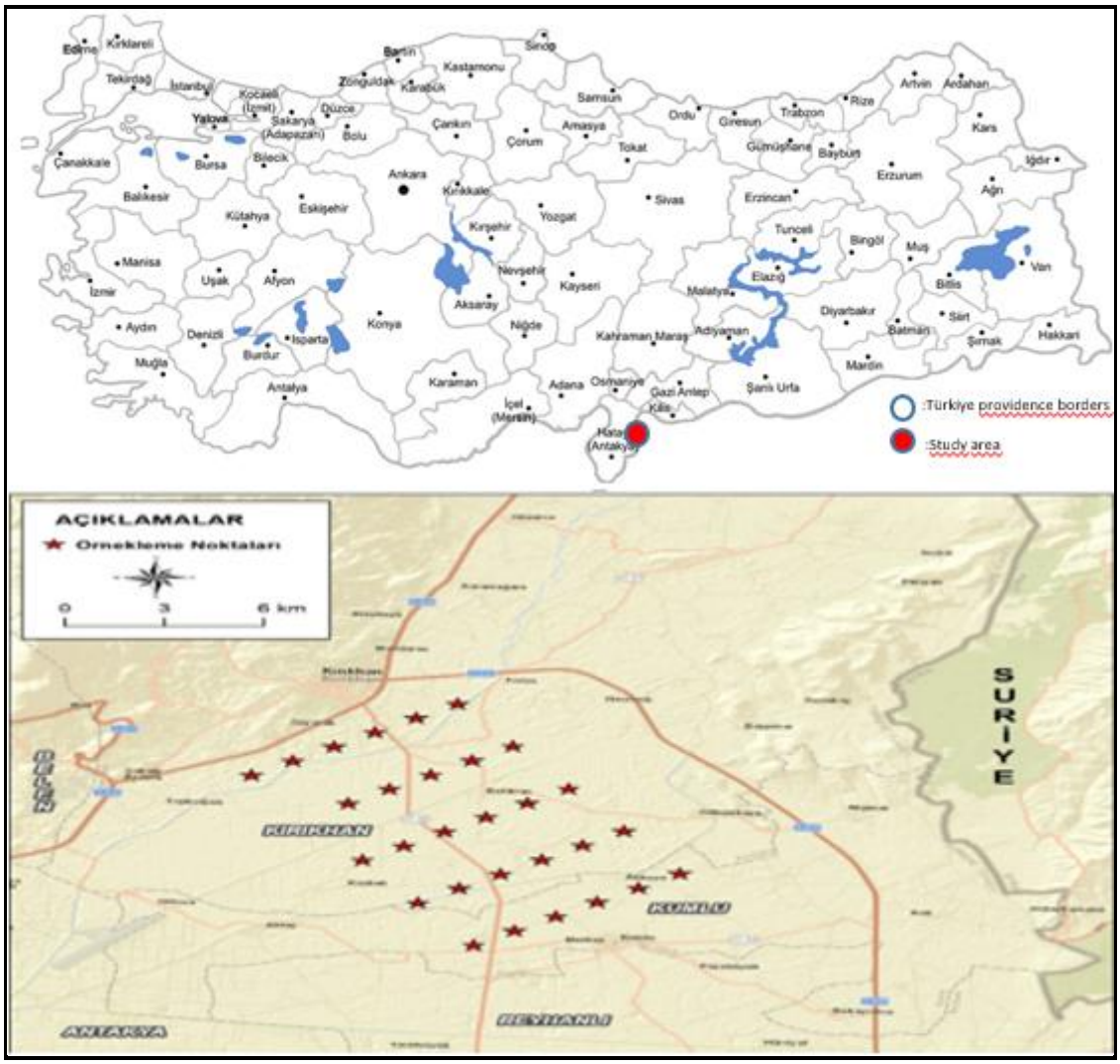

Figure 1. Map of the region where the research soils were taken

Method

Soil samples were analyzed for useful boron, pH, total soluble salt, CEC, DK (Na and K), lime, OM and composition. Useful B analysis of soils was determined by using ICP-OES in the filtrate obtained by using 0.01 M mannitol + 0.01 M $CaCl_2$ extract solution (Cartwright et al. 1983). Total soluble salt was determined from the resistivity values of the saturation sludge measured with a conductivity instrument, and pH was measured with a pH-meter in the saturation sludge (Horneck et al. 1989). CEC was determined by sodium acetate (1N pH: 8.2) extraction method (Knudsen et al. 1982). Lime ($CaCO_3$) content of soils was measured by Scheibler calcimeter (Nelson 1982), OM content of soils was determined by modified Walkley-Black method as reported by Nelson and Sommers (1982). The soil composition of the soils in the study area was determined by hydrometer method (Bouyoucos 1952).

Table 1. Locations where soil samples were taken between Reyhanlı-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)

Results and Discussion

Some physical and chemical properties of soils

The findings of some physical and chemical properties of the soil characteristics of the study area are given in Table 2. 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 (Yeter and Yalçın 2020) (Table 2). Yalçın and Çimrin (2021) working on the soils of the same region, aimed to determine the content of some macro and micronutrients in the soils of the Kırıkhan-Reyhanlı region of Hatay province and their relationship with some soil properties and to determine their fertility status and reported similar results by revealing that the pH content of the soils varied between 7.57-8.36 and that they had a slightly alkaline reaction throughout the whole area.

The lowest salt content of the soils of 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 (Table 2). Açıkel and Yalçın (2021) determined the total salt content of the soils between 0.007 % and 0.070 % and found that all the soils were in the non-saline class in the study which aimed to determine the useful boron content of the soils of Reyhanlı-Kumlu region of Hatay province and its relations with some soil properties. The lowest clay, sand and silt contents of 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 %.

Table 2. Boron content and some physical and chemical properties of Kırıkhan-Kumlu soils

Soil Number	Depth	pH	Salt %	Clay %	Sand %	Silt %	Texture Class	Lime %	O.M. %	CEC me/100gr	B mg/kg
1	0-20	8.31	0.031	46.88	17.12	36.00	C	0.94	3.18	41.17	0.30
	20-40	8.24	0.027	48.88	19.84	31.28	C	0.79	3.40	43.39	0.25
2	0-20	8.10	0.027	34.16	31.12	34.72	CL	0.63	3.25	35.74	0.15
	20-40	8.14	0.025	34.88	35.12	30.00	CL	0.47	2.96	37.13	0.45
3	0-20	8.14	0.025	44.88	17.12	38.00	C	1.10	2.81	42.26	0.20
	20-40	8.10	0.032	42.88	19.12	38.00	C	0.47	3.69	43.04	0.10
4	0-20	8.43	0.023	20.88	57.12	22.00	SCL	14.32	1.61	22.26	0.15
	20-40	8.39	0.023	18.88	59.84	21.28	SL	10.86	1.16	22.74	0.20
5	0-20	7.99	0.043	52.88	19.84	27.28	C	4.88	5.48	71.48	0.45
	20-40	8.02	0.059	54.88	17.12	28.00	C	1.73	6.08	72.83	0.30
6	0-20	8.34	0.015	28.88	41.12	30.00	CL	0.94	2.71	29.39	0.10
	20-40	8.28	0.013	28.88	45.12	26.00	SCL	0.94	2.57	30.00	0.10
7	0-20	8.02	0.033	40.88	21.12	38.00	C	21.87	3.02	38.30	0.40
	20-40	8.02	0.032	38.88	15.12	46.00	SiCL	19.04	2.69	40.22	0.30
8	0-20	7.98	0.104	32.16	15.12	52.72	SiCL	13.69	1.81	36.35	1.05
	20-40	7.95	0.109	34.88	35.84	29.28	CL	22.66	2.88	37.26	0.85
9	0-20	8.03	0.033	58.88	15.12	26.00	C	8.97	4.43	69.78	0.25
	20-40	8.02	0.058	60.88	15.12	24.00	C	14.00	4.32	64.65	0.30
10	0-20	8.06	0.050	38.88	35.84	25.28	CL	7.71	1.38	31.83	0.25
	20-40	8.13	0.041	38.88	37.12	24.00	CL	11.64	1.98	30.78	0.35
11	0-20	8.18	0.032	49.28	17.12	33.60	C	24.70	3.73	45.30	0.45
	20-40	8.16	0.051	54.16	19.12	26.72	C	18.10	2.42	45.30	0.50
12	0-20	8.06	0.033	60.16	7.12	32.72	C	16.99	2.64	45.96	0.40
	20-40	8.10	0.033	54.88	19.84	25.28	C	19.35	3.15	53.17	0.70
13	0-20	8.05	0.057	58.88	15.84	25.28	C	14.95	2.80	54.35	0.70
	20-40	8.13	0.044	58.88	11.84	29.28	C	8.34	2.64	60.74	0.70
14	0-20	8.08	0.046	64.88	14.56	20.56	C	12.75	2.84	45.61	0.95
	20-40	8.09	0.059	62.88	16.56	20.56	C	12.27	2.75	53.65	1.00
15	0-20	8.04	0.054	54.16	18.56	27.28	C	21.40	3.51	55.09	0.85
	20-40	8.00	0.059	58.16	17.84	24.00	C	22.03	2.75	53.78	0.85
16	0-20	8.20	0.043	60.16	20.56	19.28	C	15.73	2.64	48.57	0.55
	20-40	8.22	0.081	62.16	20.56	17.28	C	26.59	2.65	50.43	0.55
17	0-20	8.31	0.057	68.88	11.84	19.28	C	11.96	2.59	56.09	0.55
	20-40	8.32	0.052	70.16	14.56	15.28	C	17.15	2.57	59.70	0.50
18	0-20	8.32	0.020	36.88	16.56	46.56	SiCL	20.77	1.87	40.13	0.40
	20-40	8.28	0.021	34.16	22.56	43.28	SiCL	15.42	1.73	40.17	0.35
19	0-20	7.99	0.069	36.88	17.84	45.28	SiCL	22.34	1.94	40.13	0.85
	20-40	8.11	0.044	42.88	8.56	48.56	SiC	12.90	2.02	42.00	0.60
20	0-20	8.07	0.066	42.88	22.56	34.56	C	18.25	1.50	43.22	0.55
	20-40	8.07	0.071	38.88	26.56	34.56	CL	25.18	1.43	41.91	0.45

As can be seen in Table 2, 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) (Table 2). In the study conducted in this region, Açıkel and Yalçın (2021) aimed to determine the useful boron content of the soils of Reyhanlı-Kumlu region of Hatay province and their relationship with some soil properties and they found similar results in terms of clay, sand and silt contents of the soils.

While the lowest lime content of the study soils 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.

Table 2. (Continued)

Soil Number	Depth	pH	Salt %	Clay %	Sand %	Silt %	Texture Class	Lime %	O.M. %	CEC me/100gr	B mg/kg
21	0-20	8.31	0.028	72.16	9.84	18.00	C	19.98	2.82	61.43	1.15
	20-40	8.24	0.032	74.16	9.84	16.00	C	14.48	2.58	62.13	0.95
22	0-20	8.10	0.062	71.44	12.56	16.00	C	12.75	3.13	60.74	0.65
	20-40	8.14	0.051	71.44	12.56	16.00	C	16.68	2.97	64.96	0.95
23	0-20	8.14	0.043	67.44	10.56	22.00	C	16.36	2.90	64.83	1.00
	20-40	8.10	0.045	65.44	8.56	26.00	C	11.49	2.70	62.61	0.35
24	0-20	8.43	0.031	39.44	28.56	32.00	CL	6.45	2.45	42.00	0.40
	20-40	8.39	0.025	39.44	30.56	30.00	CL	9.28	2.07	43.26	0.30
25	0-20	7.99	0.038	59.44	12.56	28.00	C	15.11	1.79	61.91	0.25
	20-40	8.02	0.043	61.44	12.56	26.00	C	20.61	2.19	61.04	0.70
26	0-20	8.34	0.065	61.44	12.56	26.00	C	22.97	1.91	53.96	0.85
	20-40	8.28	0.074	59.44	10.56	30.00	C	20.46	1.62	54.96	1.20
27	0-20	8.02	0.043	63.44	12.56	24.00	C	17.31	2.17	60.43	1.25
	20-40	8.02	0.038	65.44	16.56	18.00	C	16.68	1.85	62.61	0.25
28	0-20	7.98	0.009	27.44	38.56	34.00	CL	14.79	1.35	28.39	0.15
	20-40	7.95	0.016	27.44	40.56	32.00	CL	14.00	1.44	31.83	0.60
29	0-20	8.03	0.022	39.44	34.56	26.00	CL	18.25	1.87	35.65	0.50
	20-40	8.02	0.047	41.44	34.56	24.00	C	16.99	1.78	39.35	0.95
30	0-20	8.06	0.076	51.44	20.56	28.00	C	19.20	2.26	68.00	0.70
	20-40	8.13	0.115	55.44	16.56	28.00	C	13.53	2.70	66.87	0.30
Min		**7.95**	**0.009**	**18.88**	**7.12**	**15.28**		**0.47**	**1.16**	**22.26**	**0.10**
Max		**8.43**	**0.115**	**74.16**	**59.84**	**52.72**		**26.59**	**6.08**	**72.83**	**1.25**
Ave.	**0-20**	**8.13**	**0.043**	**40.52**	**20.87**	**30.03**		**13.93**	**2.61**	**47.68**	**0.55**
Ave.	**20-40**	**8.13**	**0.047**	**48.88**	**22.34**	**27.18**		**13.80**	**2.59**	**49.08**	**0.53**
	Ave.	**8.13**	**0.046**	**43.31**	**21.61**	**15.28**		**13.86**	**2.60**	**48.50**	**0.54**

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 (Yeter and Yalçın 2020) (Table 2). Yalçın (2020) determined the pH, lime, organic matter and cation exchange capacity contents of Kırıkhan-Reyhanlı agricultural soils in Hatay province and found similar results in terms of lime contents of the soils.

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 (Yeter and Yalçın 2020) (Table 2). Gökpınar and Yalçın (2020) determined the pH, lime, organic matter and cation exchange capacity contents of the soils of Arsuz region of Hatay province and reported similar results by revealing the organic matter content of the soils as low and medium values above 87 %.

The lowest CEC content of the soils was 22.26 me/100g and the highest CEC was 72.83 me/100g. While the average CEC of the samples at 0-20 cm depth was 47.68 me/100g, it was 49.08 me/100g in the samples at 20-40 cm depth and 48.50 me/100g was found on average at two depths. It was determined that there were no samples in the low and medium class among the CEC values of the soil samples, 71.25 % of the samples were in the very high class and 28.75 % of the samples were in the high class. Yalçın (2020) determined the pH, lime, organic matter and cation exchange capacity contents of the agricultural soils of Kırıkhan-Reyhanlı in Hatay province and found close values in terms of cation exchange capacity of the soils.

When useful boron (B) in soil was analyzed, the lowest useful B concentration was 0.10 mg/kg and the highest useful B concentration was 1.25 mg/kg in soil samples. While the useful boron content of the soil samples

taken from 0-20 cm depth was 0.55 mg/kg, it was 0.53 mg/kg in the soil samples taken from 20-40 cm depth and 0.54 mg/kg on average. When compared according to Wolf (1971) soil boron limit values, 50.00 % of the Kırıkhan-Kumlu soils at 0-20 cm depth were very low (<0.5 mg/kg), 40.00 % were low (0.5-1. 0 mg/kg), 10.00 % were at adequate level (1.0-2.4 mg/kg), 50.00 % were at very low (<0.5 mg/kg), 43.34 % were at low (0.5-1.0 mg/kg) and 6.66 % were at adequate level (1.0-2.4 mg/kg) at 20-40 cm depth (Table 2). Yalçın and Çimrin (2017) determined the boron content of the meadow-pasture soils of Kırıkhan-Reyhanlı region of Hatay province and their relationship with some soil properties and reported similar results by obtaining very low to low values above 90% in terms of useful boron content of soils. Özkutlu et al. (2016) reported that the soils were inadequate in terms of useful boron content in the study in which they aimed to determine the B (boron) nutrition of some tea gardens in the center of Rize and their relations with soil properties.

Relationships between useful boron content and some other soil properties

The relationships between some physical and chemical properties of the investigated soil properties and their useful boron contents are given in Table 3. As can be seen from the table, a positive significant relationship was determined between useful boron and salt contents (r: 0.41***; Figure 2), clay contents (r: 0.48***; Figure 3), lime contents (r: 0.51***; Figure 4) and CEC contents (r: 0.35***; Figure 5), while a negative significant relationship was determined between useful boron and sand contents (r: -0.43***; Figure 6). In a study conducted in the same region, Yalçın and Çimrin (2017) reported similar results in the study titled "Determination of boron content of meadow-pasture soils of Kırıkhan-Reyhanlı region of Hatay province and determination of their relationship with some soil properties" by determining a positive significant relationship between useful boron content of soils and salt, clay and lime contents, while a negative relationship was found between boron content and sand content. In addition, negative correlations were determined between the pH content of soils and salt content (r: -0.29*). Positive significant relationships were determined between salt content and clay content (r: 0.28*), lime content (r: 0.36***) and CEC content (r: 0.35***), while negative relationships were determined between salt content and sand content (r: -0.30*). Yalçın et al. (2018) reported similar results by determining positive relationships between salt content and clay, lime and CEC contents of the soils, while a significant negative relationship was determined between salt content and sand content in the study which aimed to determine the macro and micronutrient status of meadow-pasture soils in Kırıkhan Reyhanlı region of Hatay province and their relationships with some soil properties and to determine their productivity status. While positive significant relationships were determined between clay content and organic matter content (r: 0.34***) and CEC content (r: 0.85***), negative significant relationships were determined between clay content and sand content (r: -0.80***) and silt content (r: -0.56***). Çimrin et al. (2019) reported similar results by determining negative significant relationships between clay contents of soils and sand and silt contents in their study aiming to determine the boron status of olive orchard soils in Nizip district of Gaziantep province. In addition, in this study, negative significant relationships were determined between sand contents of soils and organic matter contents (r: -0.32*) and CEC contents (r: -0.75***). Yalçın and Çimrin (2019) aimed to determine the boron content of large soil groups of Siverek district of Şanlıurfa province and to determine their relationship with some soil properties. They determined a significant negative relationship between sand content and organic matter content of soils and showed similar results. Negative significant relationships were determined between silt content and CEC content (r: -0.40***) and between lime content and organic matter content (r: -0.35***). At the same time, a positive significant relationship was determined between the organic matter content of the soils and their CEC content (r: 0.52***). Kars and Ekberli (2019) reported similar results by determining a significant positive correlation between organic matter content of soils and CEC content of soils in their study aiming to investigate some physical and chemical soil properties of cultivated agricultural fields in Çarşamba Plain.

Table 3. Correlation coefficients (r) between useful Boron and some soil properties of Kırıkhan-Kumlu soils

	B mg/kg	pH	Salt (%)	Clay (%)	Sand (%)	Silt (%)	Lime (%)	OM (%)
pH	-0.17							
Salt (%)	0.41***	-0.29*						
Clay (%)	0.48***	-0.08	0.28*					
Sand (%)	-0.43***	0.21	-0.30*	-0.80***				
Silt (%)	-0.20	-0.16	-0.05	-0.56***	-0.03			
Lime (%)	0.51***	-0.19	0.36***	0.24	-0.24	-0.08		
OM (%)	-0.11	-0.18	0.02	0.34***	-0.32*	-0.13	-0.35***	
CEC (me/100gr)	0.35***	-0.22	0.35***	0.85***	-0.75***	-0.40***	0.14	0.52***

* 0.05 düzeyinde önemli, *** 0.001 düzeyinde önemli

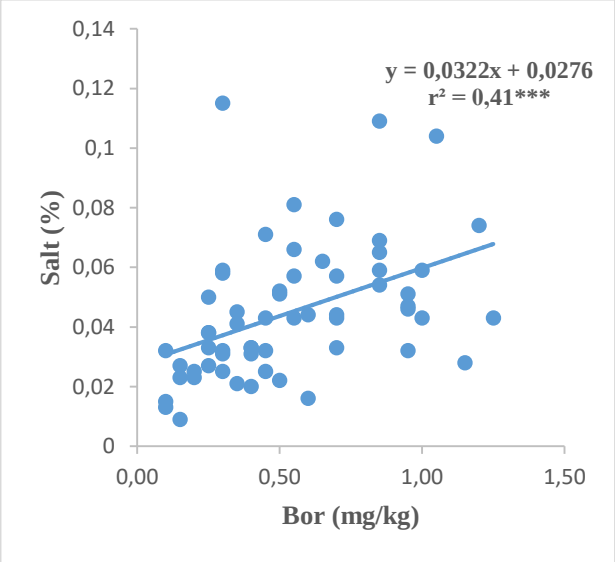

Figure 2. Relationship between useful boron and salt contents of soil samples

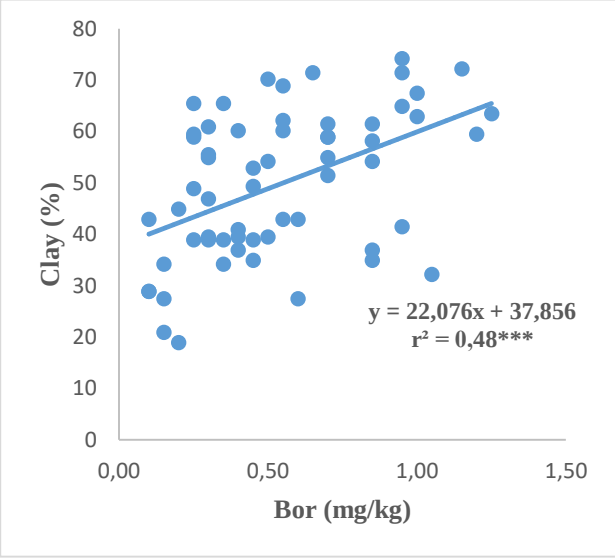

Figure 3. Relationship between useful boron and clay contents of soil samples

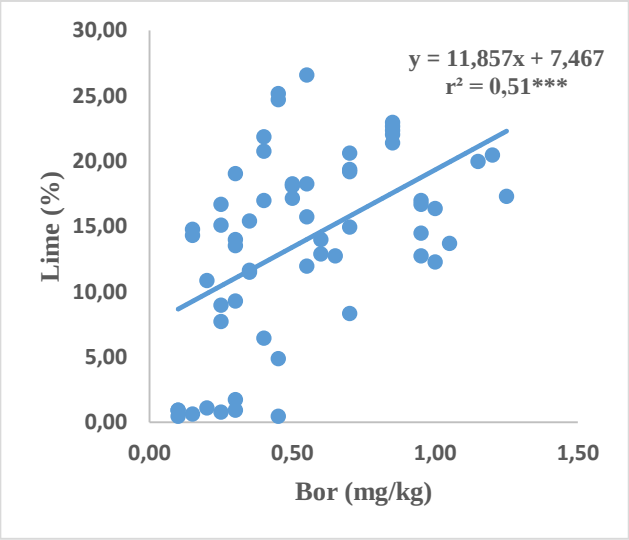

Figure 4. Relationship between useful boron and lime contents of soil samples

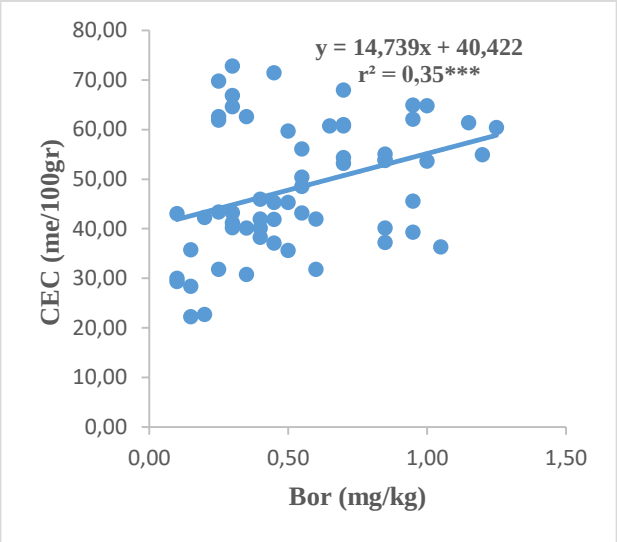

Figure 5. Relationship between useful boron and CEC contents of soil samples

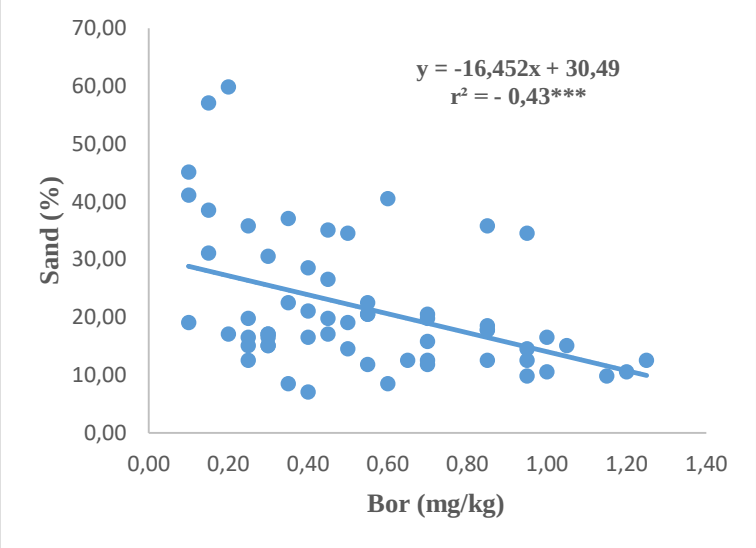

Figure 6. Relationship between useful boron and sand contents of soil samples

Conclusion

The pH values of the soils of Kırıkhan-Kumlu region of Hatay province were between 7.95-8.43 with a slightly alkaline reaction and the total salt content of the soils was determined between 0.009-0.115 % and it was revealed that all the soils of the region were classified as salt-free. The clay, sand and silt contents of the study area were determined as 18.88-74.16 %, 7.12-59.84 % and 15.28-52.72 % respectively, and nearly 85% of the soils were clay and clay loam. The lime content of the soils in the research area varied between 0.47-26.59 %, generally ranging from low to very high lime content and organic matter content ranged between 1.16-6.08 % and it was determined that the organic matter content of the soils was generally at low to medium levels. In addition, the cation exchange capacity (CEC) of the soils varies between 22.26-72.83 me/100 g and the useful B content of the soils in the study area is between 0.10-1.25 mg/kg and more than 92% of the soils contain very little to little useful B and it is determined that there is B deficiency in the study area.

When the results of the analysis of the soils of the study area are considered, it is seen that the most important problems of the soils of the study area are low organic matter, fine texture, poor drainage, high lime content and insufficient level of useful B content. It was observed that there was no salinity problem in the soils

sampled. One of the most important problems of Kırıkhan-Kumlu soils of Hatay province is the insufficient level of useful B content in the soils. Inadequate level of B content in soils means that crop production is negatively affected and the yield to be obtained is much less.

In this respect, the most important solution is to fertilize the soils with enough B-containing fertilizers to increase crop production. During the fertilization of soils, studies can be carried out to reduce the insufficient B content in soils by raising awareness of farmers to fertilize their soils with B-containing fertilizers.

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