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*** Ali Rıza ONGUN**
Orcid No: 0000-0002-5244-2770
**** Mahmut TEPECİK**
Orcid No: 0000-0001-6609-4538
***** Mehmet DÖNER**
Orcid No: 0000-0001-9993-4724

*****Ege Üniversitesi Ziraat Fakültesi Toprak Bilimi ve Bitki Besleme Bölümü (Corresponding Author)
ali.riza.ongun@ege.edu.tr

** Ege Üniversitesi Ziraat Fakültesi Toprak Bilimi ve Bitki Besleme Bölümü

*** Ege Üniversitesi Ziraat Fakültesi Toprak Bilimi ve Bitki Besleme Bölümü

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Effect of Active Carbonate on Available Micronutrients in Soils

Abstract

The primary objective of the present study was to investigate the effects of soil active carbonate contents on availability of micronutrients. A total of 20 soil samples were selected for this purpose. The lime content of the first ten samples ranged from 10.02 % to 10.99 % (CV = 3.23). The active carbonate content of these samples varied between 2.90 % and 6.95 % (CV = 34.18). There were not any significant correlations between the active carbonate and availability of micronutrients in these ten samples. The lime content of the second ten samples ranged from 30.01 % to 34.43 % (CV = 4.31). The active carbonate content of these samples varied between 6.05 % and 14.39 % (CV = 30.01). In the second ten samples, there were not any significant correlations between active carbonate and availability of micronutrients, except for Cu. A negative correlation was observed between active carbonate and available Cu (r = -0.667 *) levels.

Keywords
Active carbonate, micronutrients, soil

INTRODUCTION

The nutrients encountered at relatively low quantities in plants are so called as micronutrients (Wiedenhoeft, 2006). Such low quantities do not necessary mean that they play smaller roles in plant metabolism. Micronutrient deficiency may result in serious problems in plant and animal productions (Gupta et al., 2008). In a study conducted in Central Anatolia Region of Turkey with 2672 soil samples, significant Fe (44.8%), Zn (75.3%) and Mn (92.3%) deficiencies were reported (Akın and Taşova, 2019). It was also reported in the same study that majority of regional soils (56.1%) was quite rich in lime content. In another study conducted in the Marmora Region of Turkey with 1752 soil samples, significantly low Mn (60.1%) and Zn (54.4%) levels were reported for experimental soils (Taşova and Akın, 2013). Ongun and Tepecik (2018) investigated micronutrient contents of 513 soil samples collected from tobacco fields in Eşme town of Uşak province (Turkey) and reported significantly low Fe (52.25%), Cu (26.51%) and Zn (86.55%) levels in experimental soils. Sillanpää (1982) indicated that soils of several countries were poor in micronutrients and especially plant and soil Fe levels were quite low in Mexican and Turkish soils. It was indicated in a report prepared by eight economists, five of which have Nobel Economy Award, that vitamin A and Zn deficiency were the primary issues to be intervention especially in child nutrition (CCC, 2010). It was also indicated in the same report that five out of the top ten problems were directly related to malnutrition. Total quantities of relevant micronutrients in soils may not be meaningful all the time. Available quantities for plants are rather important in agricultural activities. Soil reaction, organic matter and carbonate content, salinity and texture-like parameters play a great role in availability of plant nutrients in soils (Özyazıcı et al., 2013).

The primary objective of the present study was to investigate the relationships between soil active carbonate contents and available micronutrients and to put fort new data for management of soil micronutrients.

MATERIALS and METHODS

Soil samples taken in 2017 from 0-30 cm soil profile of agricultural fields in Eşme town of Uşak province, located on the west of Turkey, constituted the experimental material of the present study (Table 1). Soil samples were air dried and passed through 2 mm sieves and made ready for analyses (US Soil Survey Staff, 1951). Hydrometer

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method was used to determine soil grain size distribution, in other words to find out sand, silt and clay fractions in percentages (Bouyoucos, 1962). To determine soil organic matter contents, organic carbon values determined with the use of Rauterberg and Kremkus method were multiplied by a coefficient of 1.724 and results were expressed in percentages (%) (Rauterberg and Kremkus, 1951). Soil reaction (pH) was measured with the use of a glass-electrode pH meter (Jackson, 1967). Soil salinity was measured with the use an EC meter from the samples saturated with distilled water (Jones, 2001). For available Fe, Cu, Zn and Mn contents, 20 g air-dried soil sample was extracted with 40 ml DTPA (0.005 M DTPA + 0.01 M $CaCl_2$ + 0.1 M TEA, pH: 7.3) and readings were performed in resultant extract with an Atomic Absorption Spectrophotometer (Lindsay and Norvell, 1978). Soil lime content was determined with the use of Scheibler calcimeter (Schlichting and Blume, 1966). Active carbonate contents were determined with the use of ammonium oxalate method (Özgümüş, 1999).

Table 1. Coordinates of sampling locations (UTM 35S)

sampling number	X	Y
1	669834	4236244
2	682343	4241336
3	678152	4235130
4	683160	4247138
5	682556	4240663
6	674694	4237553
7	676453	4239506
8	668891	4236740
9	674536	4237535
10	678098	4234711
11	679288	4236511
12	672384	4230221
13	672656	4238023
14	673096	4236435
15	681686	4236450
16	672729	4235950
17	683671	4242003
18	683387	4247024
19	683260	4236227
20	672613	4236572

RESULTS and DISCUSSION

Soil samples were assessed in two groups. The lime contents of the first group of 10 samples varied between 10.02 - 10.99% (CV = 3.23) and active carbonate contents varied between 2.90 - 6.955 (CV = 34.18) (Table 2). The lime content of the second group of 10 samples varied between 30.01 - 34.43% (CV = 4.31) and active carbonate contents varied between 6.05 - 14.39 (CV = 30.01) (Table 3). According to coefficient of variation, in both groups, the lowest variation was observed in soil pH and lime contents. On the other hand, active carbonate contents were highly variable (Figure 1).

Table 2. Analysis results and descriptive statistics for the first group soil samples

sampling number	pH	EC dS m^{-1}	SOM %	Sand %	Silt %	Clay %	$CaCO_3$ %	AC %	Fe mg kg^{-1}	Cu mg kg^{-1}	Zn mg kg^{-1}	Mn mg kg^{-1}
1	7.43	0.54	1.06	54.40	30.72	14.88	10.02	2.96	0.98	0.31	0.33	1.06
2	7.56	0.68	1.00	70.40	22.72	6.88	10.04	3.33	3.40	0.93	0.32	6.82
3	7.26	1.52	2.36	56.40	40.72	2.88	10.18	4.17	0.86	0.46	0.84	2.50
4	7.41	0.46	1.14	69.68	24.72	5.60	10.24	2.90	2.17	0.34	0.42	6.01
5	7.53	0.78	1.54	80.40	16.72	2.88	10.24	5.87	2.55	0.58	0.45	4.16
6	7.58	0.46	0.37	71.68	19.44	8.88	10.27	2.96	1.45	0.20	0.60	2.03
7	7.23	0.9	1.71	56.40	28.00	15.60	10.49	3.63	2.52	0.70	0.43	6.71
8	7.29	1.06	1.74	36.40	36.72	26.88	10.62	4.66	0.80	0.14	0.42	0.90
9	7.57	0.44	0.55	65.68	27.44	6.88	10.87	3.14	1.73	0.22	0.84	1.65
10	7.43	0.77	2.81	56.40	36.72	6.88	10.99	6.95	0.97	0.40	0.39	2.09
min	7.23	0.44	0.37	36.40	16.72	2.88	10.02	2.90	0.80	0.14	0.32	0.90
max	7.58	1.52	2.81	80.40	40.72	26.88	10.99	6.95	3.40	0.93	0.84	6.82
mean	7.43	0.76	1.43	61.78	28.39	9.82	10.40	4.06	1.74	0.43	0.50	3.39
sd	0.13	0.34	0.76	12.39	7.88	7.39	0.34	1.39	0.89	0.25	0.19	2.34
CV	1.78	44.34	53.53	20.06	27.76	75.19	3.23	34.18	51.02	57.80	38.26	68.93
skewness	-0.35	1.33	0.46	-0.63	0.14	1.54	0.77	1.30	0.62	0.95	1.20	0.61
kurtosis	-1.45	1.88	-0.30	0.84	-1.01	2.38	-0.62	0.78	-0.69	0.39	0.07	-1.49

SOM: soil organic matter AC: active carbonate

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Table 3. Analysis results and descriptive statistics for the second group soil samples

sampling number	pH	EC	SOM	Sand	Silt	Clay	$CaCO_3$	AC	Fe	Cu	Zn	Mn
		dS m^{-1}	%	%	%	%	%	%	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}
1	7.43	0.57	2.58	51.12	28.00	20.88	30.01	6.05	1.00	0.49	0.39	1.18
2	7.60	1.38	2.65	48.96	22.72	28.32	30.53	6.11	2.58	0.59	1.51	6.13
3	7.64	0.73	2.13	42.96	32.72	24.32	31.72	13.85	1.23	0.26	0.59	3.05
4	7.47	0.91	1.33	47.12	31.28	21.60	32.02	13.30	3.14	0.43	0.43	1.86
5	7.40	0.75	1.28	37.12	43.28	19.60	32.02	14.39	1.73	0.27	0.46	2.83
6	7.45	1.00	1.78	63.68	13.44	22.88	32.62	13.60	2.54	0.38	0.48	1.28
7	7.45	0.59	2.81	81.84	5.28	12.88	33.11	11.67	1.47	0.41	1.07	2.85
8	7.42	0.34	2.07	63.68	26.72	9.60	33.32	7.80	3.55	0.41	0.85	8.82
9	7.61	0.37	0.57	56.40	26.72	16.88	33.82	14.33	2.56	0.38	0.48	3.12
10	7.40	1.28	2.45	53.68	33.44	12.88	34.43	13.67	2.79	0.50	0.59	1.83
min	7.40	0.34	0.57	37.12	-5.28	9.60	30.01	6.05	1.00	0.26	0.39	1.18
max	7.64	1.38	2.81	92.40	43.28	28.32	34.43	14.39	3.55	0.59	1.51	8.82
mean	7.49	0.79	1.97	55.71	25.30	18.98	32.36	11.48	2.26	0.41	0.69	3.30
sd	0.09	0.35	0.72	15.37	13.23	5.86	1.39	3.44	0.85	0.10	0.36	2.40
CV	1.24	44.52	36.73	27.59	52.26	30.85	4.31	30.01	37.75	24.43	52.43	72.81
skewness	0.87	0.45	-0.75	1.56	-1.40	-0.17	-0.32	-0.94	-0.15	0.05	1.65	1.68
kurtosis	-1.11	-0.73	-0.24	3.38	2.85	-0.77	-0.52	-1.07	-1.21	0.01	2.27	2.52

SOM: soil organic matter AC: active carbonate

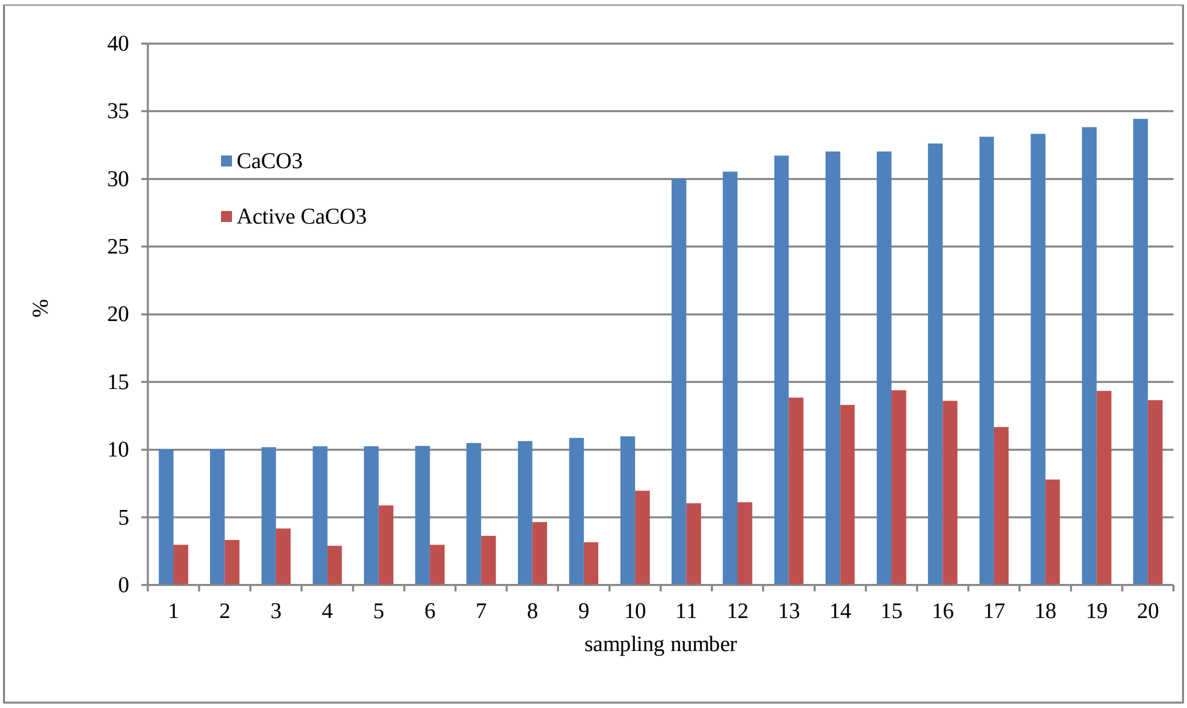

Figure 1. Lime and active carbonate contents of soil samples

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Considering the correlations between soil characteristics, there were no significant correlations between lime content and available micronutrients (Table 4). In a previous study conducted to determine soil characteristics of agricultural fields of Van province, significant correlations were reported between soil lime contents and available micronutrient levels (Çimrin and Boysan, 2006). However, in another study conducted in Rajasthan of India, significant negative correlations were reported between soil lime contents and available micronutrients (Fe, Cu, Zn, Mn) (Kumar and Babel, 2011). Çelik and Katkat (2007) conducted a study about iron nutrition in peaches and reported significant negative correlations between soil lime content and available Fe levels. A significant correlation was not observed in the first group soil samples of the present study between active carbonate contents and micronutrients. However, in the second group of samples, significant negative correlations were observed between active carbonate content and available Cu levels (-0.667*). In a previous study conducted in peach orchards with iron deficiency, significant negative correlations were reported between available Fe levels and active carbonate contents (varying between -0.438** and -0.801**) (Başar, 2000). Significant negative correlations (-0.517**) were also reported between available Fe levels and active carbonate contents of bean-cultivated fields (Şendemirci et al., 2016). There may not exist significant correlations between soil lime - active carbonate contents and available micronutrients all the time since several factors are effective in availability of micronutrients. High lime contents are encountered in soils of arid and semi-arid climate zones. Yaalon (1957) indicated that such soils may have lime contents over 30% and such high lime levels may generate specific problems in soil analyses, therefore, brought forward the concept of active carbonate as related to lime particles. Thusly, in present study, there were significant negative correlations between active carbonate and available Cu levels in the second group of soil samples with an average lime content of 32.36%.

Table 4. Correlation matrix between soil characteristics

first group	pH	Salt	$CaCO_3$	AC	SOM	Sand
pH	1.000	-0.724*	-0.062ns	-0.121ns	-0.635*	0.704*
Salt	-0.724*	1.000	-0.036ns	0.365ns	0.714*	-0.473ns
$CaCO_3$			1.000	0.492ns	0.325ns	-0.322ns
AC				1.000	0.774**	-0.111ns
SOM					1.000	-0.433ns
Sand						1.000
	Silt	Clay	Fe	Cu	Zn	Mn
pH	-0.691*	-0.444ns	0.348ns	-0.002ns	0.014ns	-0.051ns
Salt	0.656*	0.093ns	-0.310ns	0.168ns	0.272ns	-0.076ns
$CaCO_3$	0.349ns	0.167ns	-0.324ns	-0.370ns	0.229ns	-0.333ns
AC	0.265ns	-0.097ns	-0.209ns	0.068ns	-0.165ns	-0.182ns
SOM	0.684*	-0.003ns	-0.344ns	0.160ns	-0.096ns	-0.048ns
Sand	-0.825**	-0.797**	0.646*	0.366ns	0.076ns	0.455ns
Silt	1.000	0.317ns	-0.713*	-0.267ns	0.213ns	-0.443ns
Clay		1.000	-0.322ns	-0.329ns	-0.355ns	-0.291ns
Fe			1.000	0.784**	-0.305ns	0.873**
Cu				1.000	-0.341ns	0.803**
Zn					1.000	-0.342ns
Mn						1.000

second group	pH	Salt	$CaCO_3$	AC	SOM	Sand
pH	1.000	0.024ns	-0.205ns	0.035ns	-0.178ns	-0.204ns
Salt		1.000	-0.153ns	-0.007ns	0.340ns	-0.267ns
$CaCO_3$			1.000	0.586ns	-0.298ns	0.387ns
AC				1.000	-0.595ns	-0.098ns
SOM					1.000	0.371ns
Sand						1.000
	Silt	Clay	Fe	Cu	Zn	Mn
pH	-0.003ns	0.542ns	-0.134ns	-0.068ns	0.283ns	0.148ns
Salt	0.091ns	0.496ns	0.157ns	0.488ns	0.334ns	-0.192ns
$CaCO_3$	-0.122ns	-0.740*	0.483ns	-0.195ns	-0.154ns	0.058ns
AC	0.160ns	-0.104ns	0.017ns	-0.667*	-0.533ns	-0.493ns
SOM	-0.425ns	-0.014ns	-0.301ns	0.493ns	0.559ns	0.125ns
Sand	-0.927**	-0.531ns	0.014ns	0.167ns	0.347ns	0.088ns
Silt	1.000	0.175ns	0.111ns	-0.227ns	-0.453ns	0.005ns
Clay		1.000	-0.289ns	0.074ns	0.113ns	-0.242ns
Fe			1.000	0.302ns	0.133ns	0.483ns
Cu				1.000	0.520ns	0.160ns
Zn					1.000	0.617ns
Mn						1.000

* $p<0.05$ ** $p<0.01$ ns: not significant AC: active carbonate SOM: soil organic matter

CONCLUSION

Present findings revealed that active carbonate could be used as a reliable indicator for micronutrients of the soils with high lime contents and micronutrient deficiencies. However, number of studies on active carbonate is quite limited and generally focused on Fe. Active carbonate could be used as a significant parameter in soil management and cropping patterns. Considering the significance of micronutrients in human nutrition, further research is recommended to gather greater and better knowledge about micronutrients.

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