SEASONAL CHANGES OF MACRO- AND MICROELEMENTS CONTENT IN SOILS OF GREEN TEA FARMING FROM RIZE (TURKEY)

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Abstract. During 2014 year, 60 soil samples at the point of 30 soil samples in the spring and 30 soil samples in autumn were taken from the localities of Fındıklı (41°16'14.40"N - 41°08'24.13"E), Pazar (41°10'50.06"N - 40°53'11.35"E) and Sabuncular (41°04'20.79"N - 40°43'13.51"E) from Rize (Turkey), where green tea has been cultivated. The value of pH, content of the organic matter, and amount of macro- and microelements amount were determined in sampled soils and the seasonal changes were investigated. According to the obtained results, it was established that, in general, the values of pH, as well as the content of macro- and microelements in spring were higher than those recorded in autumn.

Introduction

Soil is a natural organic structure, having both mineral and organic constituents, in addition to biological, physical, and chemical features. Hence, the soil properties cannot be a simple reflexion on the connected features of all soil components. Chemical elements in soil refer to as trace elements (TEs), because of their occurrence at concentrations less than 100 mg·kg⁻¹. Many of these elements are present at concentrations much lower than this value. The most of trace elements, which have environmental and human/animal health significance, are metals, such as: cadmium, chromium, cobalt, copper, gold, lead, manganese, mercury, molybdenum, nickel, palladium, platinum, rhodium, silver, thallium, tin, vanadium and zinc. Other significant TEs belong to the metalloid (*e.g.* boron, arsenic, and antimony), non-metal (*e.g.* selenium), actinoid (*e.g.* uranium) and halogen (*e.g.* iodine and fluorine) groups of elements [1]. The combination of soils is exceedingly different and, although, controlled by many different agents, the climatic conditions and the parent material predominate most ordinarily. Soil is a combination of solid (mineral and organic section), liquid, and gaseous phases. Furthermore, not only the chemical combination of soil, but also its mineral structure and the expression of distribution are significant factors, influencing soil properties.

Trace elements have also been termed "toxic metals", "trace metals" or "heavy metals", although none of these terms is entirely satisfactory from a chemical viewpoint. "Heavy metals" is the most popularly used and widely recognized term for a large group of elements with a density greater than 6 g·cm⁻¹, but all TEs are metals [2]. Similarly, the term "toxic metals" is not suitable as TEs become toxic to living organisms only when they are at excess levels. For this reason, TEs are also frequently referred as potentially toxic trace elements (PTEs); this term is more comprehensive and appropriate than toxic or heavy metals. The term "trace element" is utilitarian as it clasps metals, metalloids, non-metals and other elements in the soil–plant–animal system, but it is somewhat indefinite, because it can incorporate any element notwithstanding of its function.

Seven elements, such as: chlorine, manganese, iron, zinc, boron, copper and molybdenum, are important nutrients required in trace amounts for plant growth, as well as human and animal health, although chlorine and iron within soils and plants are not TEs, because their average concentration is generally greater than 100 mg·kg⁻¹. These elements are necessary for maintaining the life processes in plants and/or animals, including humans and, therefore, they are important micronutrients [2]. Cobalt, chromium, fluorine, iodine, nickel and selenium found in plants are not important nutrients as such, but animals have developed a dependency on these elements for use in their metabolic procedures. Cobalt is also required by microorganisms for atmospheric-nitrogen obsession and by ruminants for their rumen bacteria. Although the biological role of these elements is not fully understood, they are considered as important beneficial TEs [3]. There is little evidence to suggest that arsenic, cadmium, lead and mercury play a nutritive role in higher plants and animals [4].

The aim of this work was (i) determination of the pH value, organic matter content, amount of the macro- and microelements and (ii) evaluation of seasonal changes of these parameters in soils sampled from Rize (Turkey), where the green tea has been cultivated.

Materials and methods
Materials

In this study, 60 soil samples at the point of 30 soil samples in spring and 30 soil samples in autumn were taken from the localities of Fındıklı, Pazar and Sabuncular, where the green tea has been cultivated in Rize (Turkey) during 2014 year. Localities Fındıklı (41°16'14.40"N - 41°08'24.13"E), Pazar (41°10'50.06"N - 40°53'11.35"E) and Sabuncular (41°04'20.79"N - 40°43'13.51"E) are given by the coordinates in Figure 1.

Figure 1. Studied regions on the map.

Preparation of soil samples

Four basic stages, which help to determine the representativeness and reliability of approach, were defined as follows: Stage 1 - pre-sampling assessment and plan; Stage 2 - soil sampling; Stage 3 - soil pre-analysis treatment (which includes soil preparation and storage); and Stage 4 - soil analysis [1]. The samples were collected from the three different sampling points (Sabuncular, Pazar and Fındıklı in Rize (Turkey)) during two different seasons (April (I) and November (II)). The most soil samples are collected using a specific corer or auger. These primary samples are subsequently either combined (composite/aggregated) or kept and analysed separately (Figure 2).

The logistics, costs, obtained information and interpretation that is likely to be gained from both of these two approaches is very different [1]. The number and relative position of the sampling points depend on the scope of sampling and, thus, on the particular sampling strategy chosen, which can be selected on a statistical basis [1]. When these primary samples are mixed together, a composite/aggregate sample is obtained. A sample ready for the laboratory can be obtained either directly from the primary sample or from the composite sample [1].
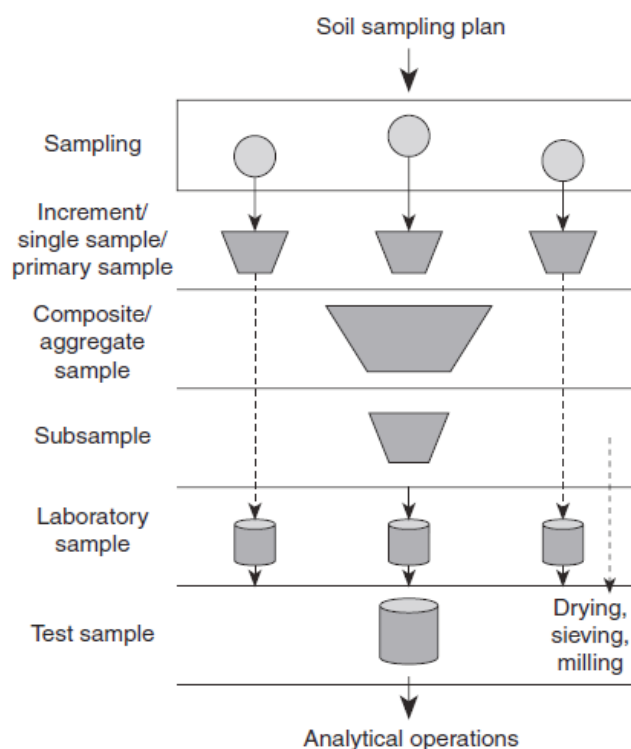

Figure 2. Sampling operations [5].

Methods

All chemicals used in this study were purchased from Merck and were of analytical grade. The value of pH, organic matter content, amount of the macro- and microelements were determined in all soil samples. Each determination was repeated 3 times.

pH value

The pH measurement was carried out after pH meter electrodes were plunged in the suspension of soil, according to the recommendations presented in [6-7].

Organic matter content

Organic matter in soil sample was digested by oxidation with acid-dichromate solution. The excess of dichromate was titrated with $KMnO_4$ solution, using ferrous(II) sulphate solution as indicator [8].

Nitrogen content

The soil sample was subjected to digestion with concentrated H_2SO_4 and solubilisation mixture (Na_2SO_4 or $K_2SO_4 + CuSO_4 \cdot 5H_2O + FeSO_4 \cdot 7H_2O$). The soil extract was titrated with boric acid in micro-*Kjeldahl* apparatus and the nitrogen content was calculated by the corresponding formula [8].

Phosphorus content

Phosphorus content in soil samples was determined after digestion by extraction solution ($NH_4F + 0.5N$ HCl). Phosphorus content was determined in filtrate solution after adding ammonium molybdate in the presence of aqueous tin(II) chloride, at 660 nm wave length [8].

Potassium content

Potassium content was determined, after digestion of soil sample by ammonium acetate, in flame photometer device [8].

Calcium content

Solution after digestion by ammonium acetate was titrated with 0.01N EDTA in the presence of ammonium purpurate in alkaline medium. The calcium content was calculated by the corresponding formula [8].

Calcium + magnesium content

Solution after digestion by ammonium acetate was titrated with 0.01N EDTA in the presence of eriochrom black - T indicator. The magnesium content was calculated by the corresponding formula [8].

Iron, manganese, zinc and copper content

The soil sample was subjected to digestion with DTPA solution (diethylene triaminepentaacetic acid + $CaCl_2$ + triethanolamine). The content of iron, manganese, zinc and copper was determined in soil extracts by using atomic absorption spectrometry (AAS) at 248.3 nm, 279.5 nm, 213.9 nm and 324.7 nm respectively.

Replaceable aluminium

Aluminium was determined by atomic absorption spectrometry (AAS) at 309.3 nm wavelength, after soil treatment with a solution of potassium chloride.

Devices

For this study the following devices were used: pH meter (Thermo Orion, X01162), spectrophotometer (Shimadzu, UV-1800), nitrogen distillation apparatus (Gerhardt, 7145110018), flame photometer (BWB XP flame photometer), age incinerator (Gerhardt, 7043130020), shaker (Selecta, 480151), atomic absorption spectrometry (GBC, Avanta T) and precision balances (Precisa, XB620M).

Results and discussion

In this study, soil samples were taken from the region of Sabuncular, Pazar and Fındıklı in Rize (Turkey) during April and November, 2014. A total of 30 soil samples was obtained from 10 different manufacturers in each region. Twelve separate analyses of each of these soil samples were performed (a total of 360).

pH value

The pH value of the tea agricultural land in Rize ranged from mild to exceptionally acidic. The pH value ranged from 3.42 to 6.12. It was determined that the pH value in the most cases was below of 4.50. In 86.6% of the soil samples the value of pH was recorded between 4.50 and 6.00, which is considered ideal for tea growing. In 76.6% of samples the exceptionally acidic pH value was registered, while 23.4% of samples had the ideal value of pH. The results for each zone and season are given in the Tables 1-3.

According to the results presented in Tables 1-3, the higher values of pH were observed in soil sampled during April. Organic fertilizers used in spring are considered as one of the reasons. It has led to the rise of pH due to the properly processing of the soil containing the applied organic fertilizer, by rainfall. In the autumn, the effect of organic fertilizer is reduced. Secondly, the drop in the pH value during November is caused by pollution through rainwater contaminated with organic fertilizer. It has led to the emergence of a significant negative effect that can be considered in the literature of the uncontrolled use of agricultural chemicals in our country and uncontrolled of manufacturers in this topic. Our tea producers have applied ammonium sulphate ($(NH_4)_2SO_4$) fertilizer in excessive quantity and one-sidedly despite all warnings. Consequently, more than 95% of our tea soils in 30 years have gained an excessive level of acidity and the pH of soil has dropped below the lower limit of pH (4.5). As a result, it appears to be compatible with the average values of pH obtained in April for tea cultivation, considering pH value of 4.5 - 6.0. The pH variation in soils of Sabuncular region is presented in Figure 3.

Table 1

Results of soil samples analyses, taken from the green tea farming in the region of Sabuncular during April (I) and November (II).

Altitude (m)	Month	pH	Organic matter content (%)	N (g/kg)	P (g/kg)	K (g/kg)	Ca (g/kg)	Mg (g/kg)	Fe (g/kg)	Mn (g/kg)	Zn (mg/kg)	Cu (mg/kg)	Al (g/kg)
430	I	5.39	7.54	3.77	0.0653	0.1030	3.3040	2.5470	0.1365	0.0485	3.9890	1.2260	0.0503
	II	4.47	3.52	1.76	0.0444	0.0667	2.4000	2.7380	0.2188	0.0428	2.8090	1.0320	0.0595
520	I	5.14	14.56	7.28	0.1133	0.2010	6.8240	4.5830	0.2997	0.0810	4.4790	4.9100	0.0422
	II	4.67	10.66	5.33	0.1113	0.1353	5.2240	4.3890	0.2396	0.1121	6.5300	5.8070	0.0595
550	I	5.21	7.98	3.99	0.0214	0.0663	3.3600	2.7940	0.1188	0.0807	3.2580	0.9960	0.1075
	II	4.35	3.46	1.73	0.0162	0.0267	2.9840	1.8590	0.1423	0.0479	1.7040	0.8940	0.1273
640	I	5.59	6.26	3.13	0.0055	0.1030	5.3360	3.6840	0.0734	0.0577	3.4880	2.3920	0.0355
	II	4.93	2.14	1.07	0.0048	0.0250	3.6800	2.9540	0.1315	0.0788	3.7790	2.1700	0.0421
680	I	4.76	6.76	3.38	0.0147	0.0947	1.3360	1.3970	0.2124	0.0309	3.1040	1.9790	0.6694
	II	3.91	3.36	1.68	0.0112	0.0440	0.9600	0.9860	0.2630	0.0603	2.2010	1.2620	0.6763
700	I	5.52	7.26	3.63	0.0549	0.0983	4.9040	1.9860	0.1620	0.0853	5.5930	4.8280	0.0225
	II	4.38	3.54	1.77	0.0336	0.0650	3.6800	1.3740	0.1840	0.1042	6.5420	3.5110	0.0347
750	I	4.50	17.26	8.63	0.1286	0.1253	5.4400	1.6950	0.3941	0.0158	3.3890	1.2010	0.1540
	II	3.72	13.52	6.76	0.0781	0.0780	4.0000	1.2940	0.2753	0.0104	4.4530	3.0270	0.1952
770	I	4.77	7.38	3.69	0.0649	0.1383	3.6240	3.8290	0.2296	0.0558	4.0810	3.1110	0.2514
	II	4.23	5.50	2.75	0.0444	0.0947	2.2400	1.7380	0.2589	0.0780	4.9390	2.9680	0.2881
770	I	4.32	11.86	5.93	0.0540	0.1290	2.9360	2.7430	0.4081	0.0219	2.4970	1.0690	0.4772
	II	3.70	8.08	4.04	0.0256	0.0663	1.9760	1.3820	0.2806	0.0252	2.9710	1.5320	0.4973
770	I	4.63	8.62	4.31	0.0653	0.1670	2.7760	1.3820	0.2760	0.0515	3.6360	2.7490	0.3717
	II	3.73	5.44	2.72	0.0362	0.0970	1.5440	1.0930	0.2812	0.1006	4.2060	2.4970	0.4126

Table 2

Results of soil samples analyses, taken from the green tea farming in the region of Pazar during April (I) and November (II).

Altitude (m)	Month	pH	Organic matter content (%)	N (g/kg)	P (g/kg)	K (g/kg)	Ca (g/kg)	Mg (g/kg)	Fe (g/kg)	Mn (g/kg)	Zn (mg/kg)	Cu (mg/kg)	Al (g/kg)
160	I	5.44	9.82	4.91	0.0136	0.6703	47.3040	5.3480	0.0539	0.0407	2.6310	1.5440	0.0411
	II	4.34	2.74	1.37	0.0087	0.4653	31.8960	3.6280	0.1911	0.1428	1.1680	1.6800	0.0595
165	I	5.10	6.32	3.16	0.0592	0.6617	8.4800	1.1250	0.1737	0.0362	4.0700	3.4670	0.2954
	II	4.21	5.62	2.81	0.0474	0.5807	5.1760	0.7690	0.3174	0.0565	1.3870	3.6900	0.0595
170	I	5.12	8.24	4.12	0.0502	0.3093	2.8800	12.9470	0.0854	0.0360	2.1170	1.3280	0.0533
	II	4.16	4.14	2.07	0.0076	0.2087	1.3360	11.2570	0.2429	0.0638	3.0090	0.5510	0.1273
175	I	4.94	6.98	3.49	0.0172	0.0767	1.2800	2.5750	0.0444	0.0235	0.6930	0.3200	0.7886
	II	3.68	4.20	2.1	0.0034	0.0350	0.6960	0.9480	0.1359	0.0192	0.7740	0.1940	0.0421
270	I	4.34	8.76	4.38	0.0109	0.2350	0.9040	0.9780	0.0528	0.0356	1.5590	0.1640	0.4952
	II	4.01	4.42	2.21	0.0030	0.0890	0.7440	0.4580	0.1425	0.0246	3.1640	0.2930	0.6763
290	I	4.90	7.42	3.71	0.0547	0.0713	5.6000	1.1450	0.0925	0.0235	1.6650	0.7070	0.6666
	II	4.19	5.58	2.79	0.0242	0.0460	4.6960	0.9480	0.1387	0.0354	1.0480	0.3160	0.0347
310	I	4.97	7.24	3.62	0.0132	0.3193	8.8000	2.3670	0.0819	0.0395	3.6540	1.3310	0.5787
	II	3.88	4.88	2.44	0.0085	0.2427	5.3840	1.4830	0.1413	0.1033	1.3620	0.5090	0.1952
315	I	5.25	8.40	4.2	0.0362	0.4853	2.6640	4.6360	0.0591	0.0240	1.3510	1.5400	0.0937
	II	4.13	3.54	1.77	0.0078	0.2110	1.4400	3.8290	0.1047	0.1016	1.8450	1.3000	0.2881
320	I	5.18	6.42	3.21	0.0134	0.0683	13.6000	1.9680	0.0795	0.0390	1.6750	1.1780	0.1672
	II	4.89	5.02	2.51	0.0042	0.0570	10.3440	0.9790	0.1782	0.0750	0.6250	0.5270	0.4973
330	I	5.45	4.44	2.22	0.0338	0.7950	11.8960	14.5680	0.0399	0.0399	1.4270	0.6990	0.1129
	II	5.13	2.78	1.39	0.0203	0.7113	8.2160	11.2840	0.0783	0.1369	2.7000	1.2510	0.4126

Table 3

Results of soil samples analyses, taken from the green tea farming in the region of Fındıklı during April (I) and November (II).

Altitude (m)	Month	pH	Organic matter content (%)	N (g/kg)	P (g/kg)	K (g/kg)	Ca (g/kg)	Mg (g/kg)	Fe (g/kg)	Mn (g/kg)	Zn (mg/kg)	Cu (mg/kg)	Al (g/kg)
200	I	5.07	3.38	1.69	0.0282	0.1227	4.5840	2.4020	0.1262	0.0282	3.2210	2.6770	0.0465
	II	4.35	2.40	1.2	0.0047	0.0680	2.8240	1.5560	0.0656	0.0763	3.6480	0.2700	0.0595
235	I	6.12	7.44	3.72	0.0289	0.5257	10.6640	2.6260	0.1879	0.0228	4.7910	7.5810	0.0168
	II	5.12	4.16	2.08	0.0239	0.3190	7.0960	1.2980	0.0779	0.0666	1.0250	0.1840	0.0357
240	I	4.59	6.88	3.44	0.0300	0.2233	3.5760	0.5200	0.2360	0.0034	2.4320	2.7000	0.1528
	II	3.63	4.70	2.35	0.0279	0.1027	2.0800	0.4860	0.2808	0.0140	1.4650	0.1050	0.1975
250	I	4.37	7.28	3.64	0.0497	0.1007	2.1840	0.1310	0.1654	0.0114	2.6460	2.8660	0.3745
	II	3.42	2.22	1.11	0.0117	0.0767	1.1760	0.0340	0.1726	0.0215	2.8920	1.5520	0.4435
255	I	5.26	4.30	2.15	0.0293	0.1557	2.7200	0.6470	0.1362	0.0084	3.2370	3.3060	0.1042
	II	4.44	3.26	1.63	0.0211	0.0780	1.5440	0.2630	0.1702	0.0261	3.5500	1.5460	0.1236
260	I	4.55	9.78	4.89	0.0073	0.0710	1.0160	0.2630	0.0797	0.0085	2.3680	1.1230	0.3293
	II	3.76	4.56	2.28	0.0047	0.0583	0.4240	0.1460	0.0449	0.0177	2.5580	0.5010	0.3631
280	I	5.41	6.38	3.19	0.0080	0.4993	5.4960	0.9040	0.1258	0.0317	3.3710	2.5580	0.0397
	II	4.92	3.64	1.82	0.0076	0.3343	4.6960	0.2920	0.0717	0.0527	0.6980	1.4710	0.0463
285	I	5.02	5.04	2.52	0.0085	0.4133	5.7600	0.8410	0.1203	0.0309	2.5830	1.7250	0.0886
	II	4.55	3.20	1.6	0.0065	0.3433	3.6240	0.6470	0.0682	0.0833	3.4430	0.6380	0.1222
320	I	4.95	6.54	3.27	0.0159	0.3360	3.4640	0.8070	0.0790	0.0191	2.1480	2.0380	0.1307
	II	3.84	4.10	2.05	0.0104	0.2427	1.9760	0.5830	0.0959	0.0448	2.5260	0.8580	0.1531
340	I	5.56	7.40	3.7	0.0483	0.4333	8.8560	1.9450	0.1998	0.0177	4.7500	4.9620	0.0430
	II	4.43	4.76	2.38	0.0057	0.3093	6.0240	1.0990	0.0693	0.0430	0.8800	0.0480	0.0580
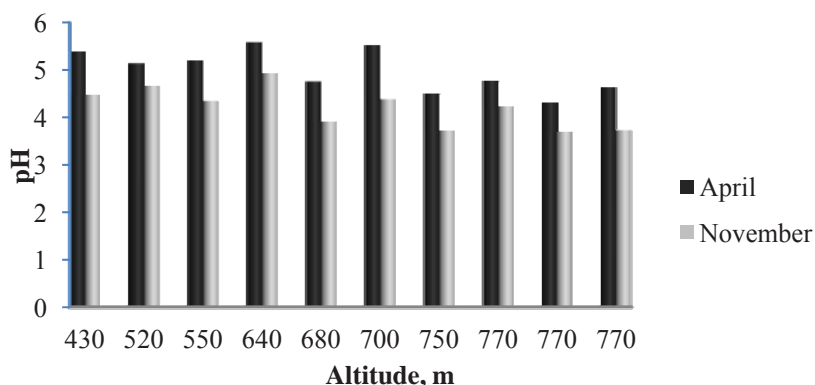
**Figure 3.
Variation of pH value
in soil sampled from
Sabuncular region.**

Organic matter content

In 13.3% of soil sampled during April the organic matter content was at high level, while in 86.7% of samples was at very high level. During November there were registered the following results: in 16.7% of samples the organic matter content was at medium level, in 73.3% - at high level and in 10.0% - at very high level. Similar results were identified in another study in Rize [9]. The values of organic matter content vary widely in soil of tea garden during April and November. This is explained by the fact that each month is characterized by abundant rainfall and low temperatures. Dynamics of organic matter content registered in Sabuncular region is shown in Figure 4.
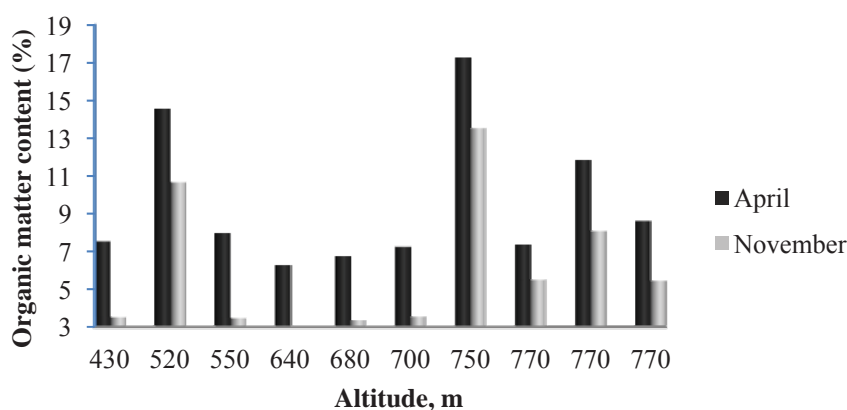
**Figure 4.
Variation of organic matter
content in soil sampled
from Sabuncular region.**

Nitrogen content

The nitrogen content in soil samples ranged from 1.1 g/kg to 8.6 g/kg. In 10% of soil sampled during April the nitrogen content was at high level, while in 90% of samples was at very high level. During November there were registered the following results: in 16.7% of samples the nitrogen content was at medium level, in 56.7% - at high level and in 10.0% - at very high level. The nitrogen ratio was similar to organic matter content. Thus, we can conclude that nitrogen is originated from organic matter in the soil.

A dynamics of nitrogen content in a study conducted between 1978 - 1982 years for 1667 soil samples at same region was reported [10]. Also, Müftüoğlu *et al.* determined the nitrogen content of the tea garden soils, classifying them as group of low, medium, high and very high [11]. There were identified the following groups: 3.78% low, 16.09% medium, 40.59% high and 39.53% very high in a study of soil samples [12]. It appears that these values are compatible with our results. The variation of nitrogen content recorded in Sabuncular region is presented in Figure 5.

Phosphorus content

The phosphorus content in soil sampled in April and November ranged from 0.0030 g/kg to 0.1286 g/kg. Comparing the obtained results with results performed in another study in the same region, which include research of 1815 soil samples [10], the increasing of phosphorus content in the soil was observed.

The phosphorus amount in samples taken in November was lower than the phosphorus content in samples collected in April. The reason is a reduction of pH value in soils. In soil phosphorus reacts with Al, Fe, Mn and insoluble hydrated oxides of these elements under acidic conditions, with Ca and Mg - in alkaline conditions. Phosphorus is a nutrient, being the most affected by the soil reaction. From the soil, plants often use the HPO_4^{-2} and $H_2PO_4^-$ form of phosphorus. Plants utilize phosphorus in the form of $H_2PO_4^-$ when pH value is lower than 6.71 and in the form of HPO_4^{-2}

when pH value is higher than 6.71. The solubility of the phosphate increases when the amount of alkali metal salts in the soil augments, depending on pH value. As a result, the plant benefits the phosphorus at pH values in limits of 5-7. Phosphorus content variation identified in Sabuncular region is shown in Figure 6.
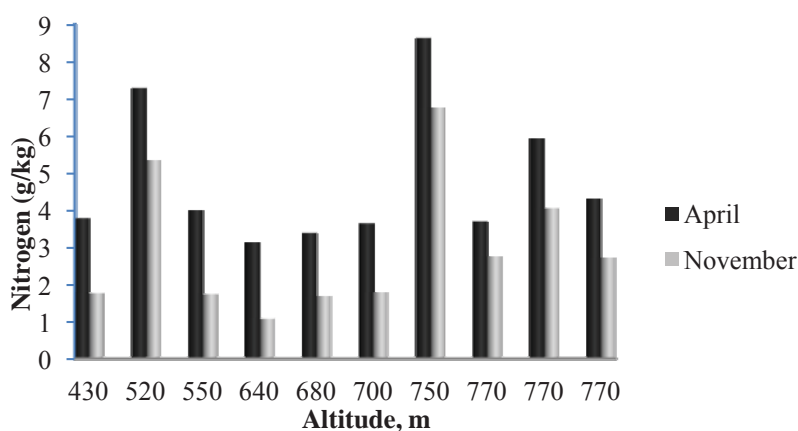

Figure 5.
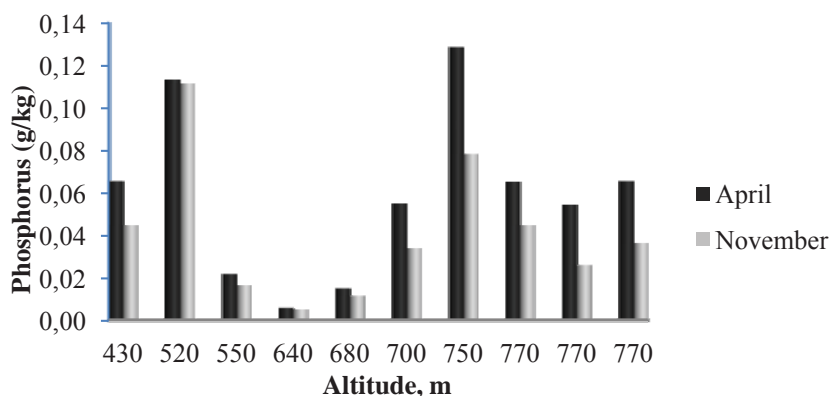**Variation of nitrogen content in soil samples from Sabuncular region.**

Figure 6.
Variation of phosphorus content in soil samples from Sabuncular region.

Potassium content

In soil sampled during April in 46.7% of samples the potassium content was at low level, while in 26.7% of samples was at sufficient level, and in 26.6% - at high level. During November there were registered the following results: in 16.7% of samples the potassium amount was at very low level, in 46.7% - at low level, in 26.6% - at sufficient level and in 10.0% - at very high level. By comparing our results with the results of another study in the same region, which include research of 1678 soil samples [13], it is observed an increasing the potassium amount in the soil.

Potassium content in the samples taken in November was lower than the potassium levels in April. It can be stated that decreasing the pH value, increasing the precipitation quantity and freeze-thaw phenomena in the soil are the reasons for this fact. It is not exactly determined that increasing the potassium level in the soil depends on the pH value. It is accepted as a general rule that the potassium level increases in the conditions of high pH [14]. Potassium amount dynamics in soils sampled from Pazar region is presented in Figure 7.
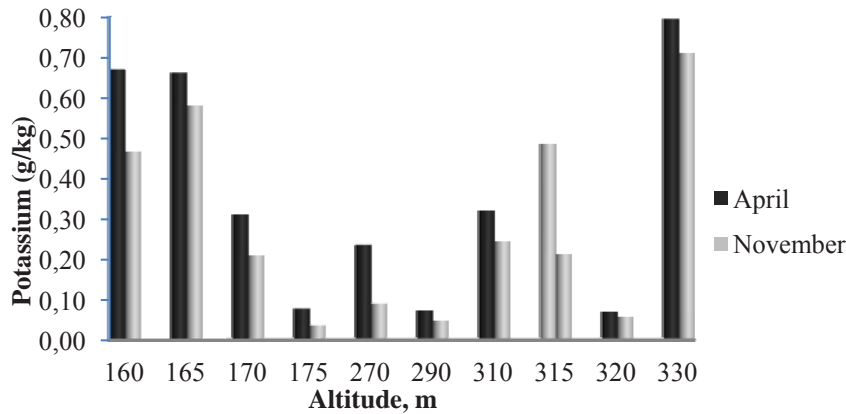
Calcium content

The calcium content in soil sampled in April and November ranged from 0.424 g/kg to 47.304 g/kg. Calcium content values in soil samples were higher than the normal values during both seasons. In 36.7% of the samples taken in the spring and in 40.0% of the samples taken in the autumn the calcium content had the desirable values. The dynamics of calcium content in soils sampled in Pazar region is shown in Figure 8.
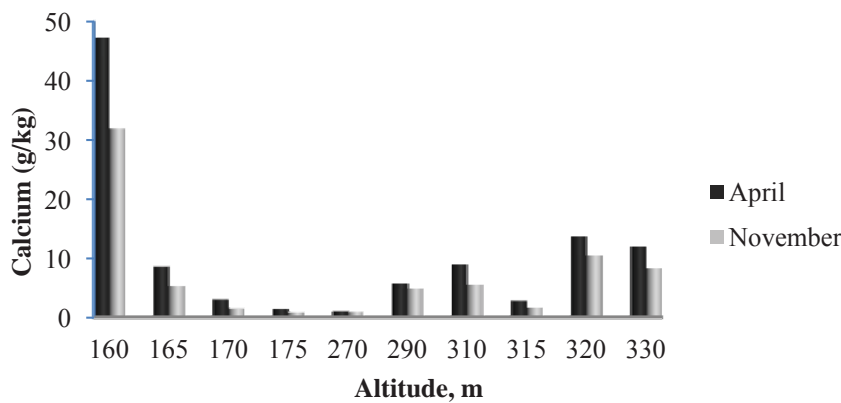
Magnesium content

In soil sampled during April in 3.3% of samples the magnesium content was at sufficient level, while in 33.4% of samples was at high level, in 60.0% - at very high level. During November there were registered the following results: in 10.0% of samples the magnesium amount was at sufficient level, in 50.0% - at high level, in 33.3% - at very high level. The values of magnesium content in the soil samples were higher than the normal values during both seasons. In 3.3% of the samples taken in the spring and in 10.0% of the samples taken in the autumn the magnesium content had the desirable values. A dynamics of magnesium content in soils sampled in Pazar region is shown in Figure 9.
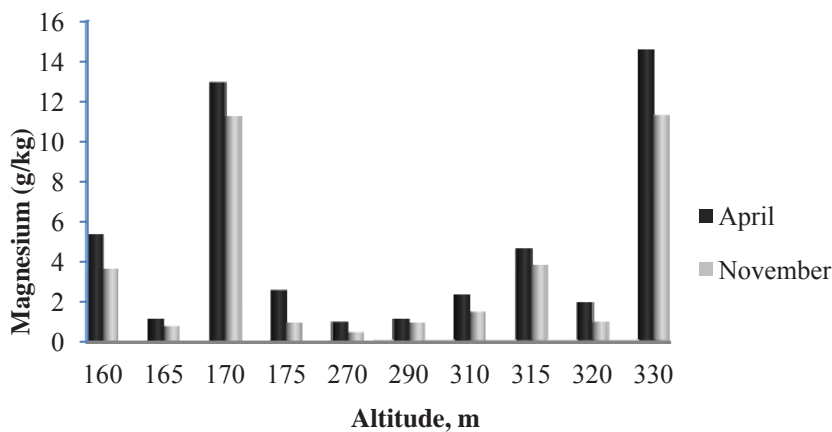
Figure 7.
Variation of potassium content in soil samples from Pazar region.

Figure 8.
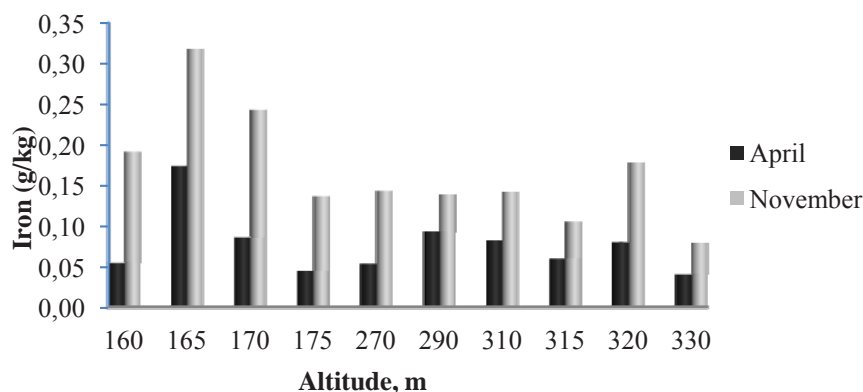**Variation of calcium content in soil samples from Pazar region.**

Figure 9.
Variation of magnesium content in soil samples from Pazar region.

Iron content

The iron content of samples taken in April was at medium level in 6.7% of samples, at a high level in 40.0% of samples and at a very high level in 53.3% of samples. In November the iron amount was registered at medium level in 3.3% of samples, at a high level in 26.7% of samples and at a very high level in 70.0% of samples. In 40.0% of samples taken in the spring and in 26.7% of samples collected in the autumn the iron content had the desirable values. The reason is the decline of pH value between the two seasons. The higher values of pH in the spring cause the iron content decreasing, whereas the fall in pH values in autumn causes the iron content increasing above the normal values.

It was determined that the values of iron content ranged between 0.0036–0.0448 g/kg in a study conducted in 8 gardens between the years of 1977-1978 in the same region [14]. Taking into account these data, it seems to be an increase in values of iron amount in our tea land. Toxic effects causing an excess of soluble iron in plants, which lack of useful iron content, contribute to excessive iron deficiency in some soils. The variation of iron content in soil sampled in Pazar region is presented in Figure 10.

**Figure 10.
Variation of iron content in
soil samples from
Pazar region.**

Manganese content

The manganese content in samples taken in April was at medium level in 76.7% of samples and at a very high level in 23.3% of sample. In November the manganese content in 36.7% of samples was at medium level, in 40.0% of samples – at high level and in 23.3% of samples – at very high level. In 23.0% of samples taken in the spring and in 40.0% of samples taken in the autumn the manganese amount had the desirable values. It is determined the manganese values ranged between 0.0019–0.0405 g/kg in a study conducted in 8 gardens between the years of 1977-1978 in the same region [15]. As a result, an increase in the value of manganese content was observed in samples taken in November. The variation of the manganese amount in soil sampled in Fındıklı region is shown in Figure 11.
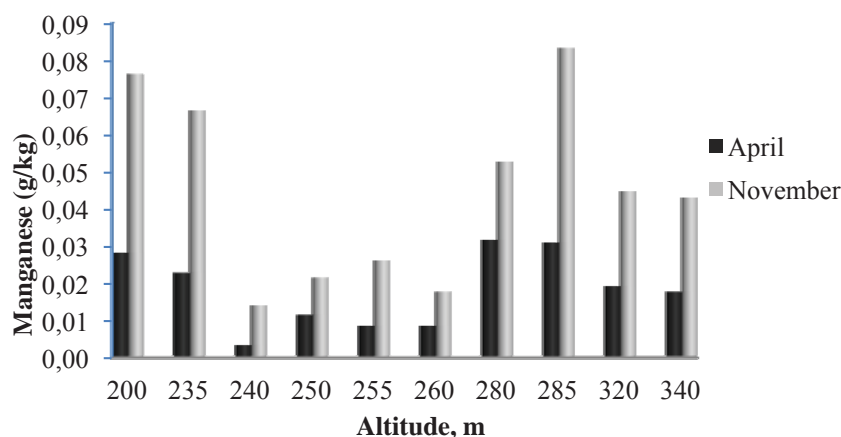
**Figure 11.
Variation of manganese
content in soil samples from
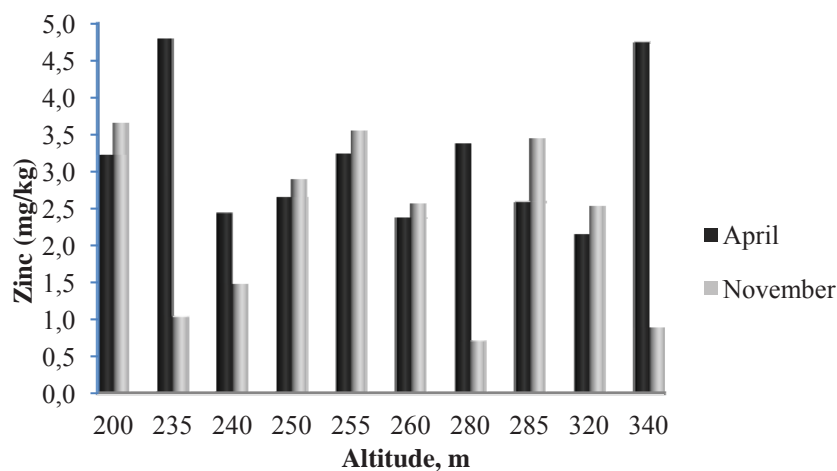Fındıklı region.**

Zinc content

The zinc content in samples taken in April was at medium level in 20.0% of samples and at a very high level in 80.0% of samples. In November the zinc amount was at medium level in 40.0% of samples and at a high level in 60.0% of samples. In 80.0% of samples taken in the spring and in 60.0% of samples taken in the autumn the zinc amount had the desirable values. The amount of zinc ranged between 0.12–4.05 mg/kg in a study conducted in 8 gardens between the years of 1977-1978 in the same region [15]. As a result, a decrease in the value of zinc content was observed in samples collected in November. The variation of zinc content in soil sampled in Fındıklı region is shown in Figure 12.
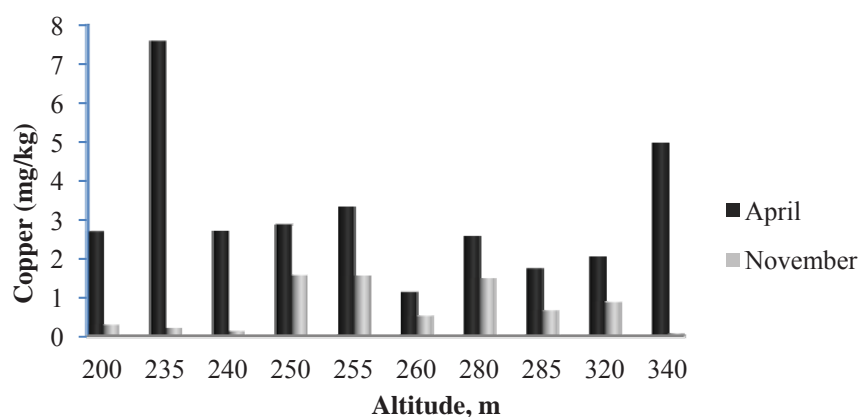
Copper content

The copper content in samples taken in April was in 16.7% of samples at medium level, in 80.0% - at a high level and in 3.3% - at a very high level. In November the copper content was in 46.7% of samples at medium level and in 53.3% - at a high level. The copper content ranged between 0.06–5.93 mg/kg in a study conducted in 8 gardens between the years of 1977-1978 in the same region [15]. As a result, an increase in the value of the copper amount was observed in soil sampled during two seasons. Dynamics of the copper amount in soil sampled in Fındıklı region is presented in Figure 13.
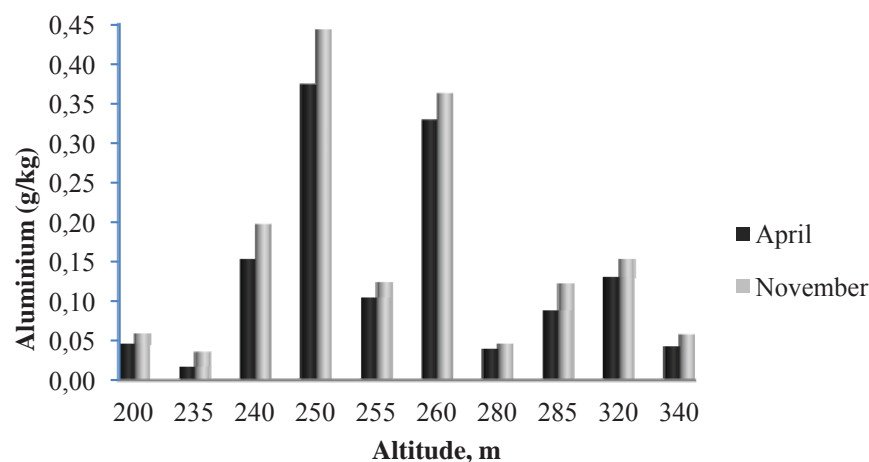
Aluminium content

The aluminium content in samples taken in April was at low level in 63.3% of samples and at medium level in 36.7%. In 53.3% of samples it was at low level and in 46.7% at medium level during November. The variation of aluminium content in soil sampled in Fındıklı region is shown in Figure 14.

Figure 12.
Variation of zinc content in soil samples from Fındıklı region.

Figure 13.
Variation of copper content in soil samples from Fındıklı region.

Figure 14.
Variation of aluminium content in soil samples from Fındıklı region.

Conclusions

Commercial fertilizers, especially on the basis of nitrogen and phosphorus, are often used unconsciously in tea growing areas in Turkey. Soil reaction has been gradually acidic and the soil productivity began to be lost as a result of manufacturers, especially using ammonium sulphate fertilizer alone and overmuch. The amount of products to be received per unit area will be high-quality as long as soil fertility status is at an appropriate level. Therefore, the promotion and protection of soil productivity level is important.

Despite the depletion or decrease in the use of ammonium sulphate fertilizer in many platforms and the expression used for the location of compound fertilizer, tea manufacturers have not outgrown their habits but continued to use ammonium sulphate fertilizer for years. In order to avoid the acidity increasing of the soil it is recommended to use composite fertilizer (with ammonium sulphate) instead of using ammonium sulphate alone.

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