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SOME PHYSICAL AND CHEMICAL PROPERTIES OF TEA GROWN SOILS IN RİZE AND ARTVİN PROVINCES

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ABSTRACT: In this study, it was aimed to show the soil productivity of tea growing areas which contain have some distinct features compared to the other areas. Therefore, 220 soil samples were taken and analyzed. Soils in the tea production areas of Rize and Artvin were clay-loamy and clay. In relation to soil reaction 90 % of the soils taken pH had values below the recommended values for tea production. These soils were found to be nonlime and contained high amounts of organic matter and available P and K.
Key Words: Tea soils, organic matter, pH, phosphorus, potassium

RİZE VE ARTVİN YÖRESİ ÇAY TARIMI YAPILAN TOPRAKLARIN BAZI FİZİKSEL VE KİMYASAL ÖZELLİKLERİ

ÖZET: Bu çalışmada, Türkiye genelinden birçok özellikleri ile ayrıcalık gösteren çay tarımı yapılan toprakların verimliliğinin ortaya konması amaçlanmıştır. Bu amaca uygun olarak 220 adet toprak örneği alınmış ve analizleri yapılmıştır. Araştırma sonuçlarına göre; Rize ve Artvin yöresi çay topraklarının genel olarak killi-tınlı ve killi bünyeli olduğu ve toprak reaksiyonu bakımından alınan örneklerin % 90'ının çay için ideal kabul edilen pH değerlerinin altında yer aldığı tespit edilmiştir. Çay topraklarının kireç içermediği, organik madde bakımından oldukça iyi durumda olduğu, yüksek oranda yarayışlı fosfor ve potasyum içerdiği belirlenmiştir.
Anahtar Sözcükler: Çay toprakları, organik madde, pH, fosfor, potasyum

1. INTRODUCTION

Tea plant is grown between the 42° latitude in Northern hemisphere and 27° latitude in Southern hemisphere. Tea can be grown in certain regions with rainy and warm climatical conditions. India, China, Sri Lanka, Indonesia, Kenya and Japan are among the major tea growing countries. Tea is grown at economical level in 30 countries including Turkey. Turkey ranks sixth among the tea producing countries with 76.632 ha production area and 201.663 tonnes dry tea production (Anonymous, 2006 and 2009).

Tea is grown on the area between Georgian border and Fatsa in the Eastern Black Sea region. The most important part within this broad tea production area is found between Georgia border and Araklı district of Trabzon (length: 7-8 km and altitude: 400-500 m). Tea production area covers 30 and 70% of the farm areas in the Eastern Black Sea region. This product forms an important source of subsistence for nearly 200.000 producers.

It is impossible to widen the tea production areas because of topographic structure of the Eastern Black Sea region. For this reason, tea yield per unit area should be increased in order to enhance the tea production. To achieve this aim, soil fertilities should be maintained and increased. One of the provisions of obtaining ample and high-quality production is to supply the nutrient requirements of plants from the soils at adequate level. Tea plant removes high amounts of nutrients from the soil every year like many agricultural products. Another reason for the removal of the nutrients from the soil is soil washing due to the rainy climatic conditions of this region. Thus, the unique way for keeping the nutrient contents of soils at adequate level is to fertilize them with fertilizer types using suitable application methods.

Fertilizer is the most important input in tea farming. Commercial fertilizers (mainly N and P fertilizers) are used unconsciously in Rize and Artvin provinces, especially in tea farming, as in other many regions in Turkey. Use of ammonium sulfate fertilizers at high level for long years increased acidity in tea soils and consequently pH values decreased below the critical value in 85% of the tea soils. Unconscious use of fertilizers increases waste, production, income and soil pollution decreases fertilities of the soils.

The main factor for agricultural production is soil. The amount and quality of the products obtained from unit area will be higher if the soil fertility is at adequate level. For this reason, it is very important to maintain and increase the fertility of the soils. The soils which contain soil nutrients at adequate level and which have suitable physical, chemical and biological properties are considered as productive soils. Thus, many factors should be taken into consideration when the soils are evaluated in terms of productivity.

The data related to the distribution of the soils according to the different pH values were found as follows in a study conducted in Rize and Artvin between 1958 and 1960: <4 pH values were 0 and

0.12%, pH=4.00-4.50 were 7.42 and 0.70%, pH=4.50-5.00 were 36.75 and 22.10%, pH=5.00-5.50 were 33.85 and 30.90%, pH=5.50-6.00 were 17.16 and 39.70%, pH=6.00-6.50 were 4.58 and 6.10%, for Rize and Artvin provinces, respectively. In this study, available P values were found extremely low at 45% of the total production area, low at 28% of the total production area, medium level at 15% of the total production area, adequate level at 7% of the total production area and excess level at 4% of the total production area.

The pH values found for the tea soils in the Eastern Black Sea region by different researchers were 2.92-5.82 (Özuygur et al., 1974), 3.67-5.53 (Kacar et al., 1979) and 3.38-5.91 (Müftüoğlu, 1990).

Soil analyses made in Rize and Artvin provinces between 1978 and 1982 showed that low available K content found for 33.22% of the tea soils in Rize, medium available K content for 42.18% and extremely higher K content for 24.60%. The corresponding values were 49% (low available content), 37% (medium available content) and 14% (higher available content) in Artvin. Available P content was found to be deficient in 87% of the tea soils in Rize and 74% of the tea soils in Artvin (Sarımehmet, 1987).

Müftüoğlu and Sarımehmet (1993a), found that 68.53% of tea soils in Rize had extremely low pH values (<4.5). The ratio of tea soils with optimum pH value (4.50-6.00) were found as 30.21%. The corresponding values for Artvin province were 45.5% and 54.0%, respectively. Of the tea soils in the Eastern Black Sea Region 62.20% had pH values below 4.5.

Müftüoğlu and Sarımehmet (1993b) found a deficiency in available P content in 84% of the tea soils in Rize province. In the same study available P content was found at medium or high level in 15.81% of the tea soils. While 73% of the tea soils in Artvin province were found deficient in terms of available P, the rest (27%) were found adequate.

In a study conducted in Rize and Artvin provinces between 1978 and 1982, 1183 samples from Rize and 186 samples from Artvin were analyzed and the following results were obtained: 18% of the samples taken from Rize province were found lower (0-2%) in terms of organic matter content, 19.2% were found medium level (2-3%) and 63% were found higher (>3%). The corresponding values for Artvin province were 9% (lower), 15.6% (medium level) and 75% (higher) (Sarımehmet ve Müftüoğlu, 1993).

In Rize and Artvin provinces, agricultural facilities are conducted on the uneven land under the climatical conditions which are not suitable for growing many plant varieties. In such a case, this limited agricultural land should be used efficiently to benefit from agricultural sector. Otherwise, loss of tea soils will be inevitable in the near future. For this reason, in this study, it was aimed to determine the productivities of the soils after evaluating the physical and chemical analysis results of the tea soils.

2. MATERIALS AND METHODS

2.1. General Description of The Study Area and Land Structure

This study was conducted in tea production areas with higher tea production potential. These production areas are under the authority of 36 tea processing factories of ÇAYKUR. This study was conducted on the areas between the Sarp village found at the Georgia border and Of district of Trabzon. The study area extends some 7-8 kms inland (even 35 kms at some parts) from the coast. The soil samples were taken from the tea plantations found in Borçka, Kemalpaşa, Hopa and Arhavi districts of Artvin, and Fındıklı, Ardeşen, Pazar, Çayeli, Gündoğdu, Merkez, Güneysu, Kalkandere, İyidere and Derepazarı districts of Rize province. The study areas are situated between the 40^{o}15'-41^{o}34' North latitudes and 36^{o}43'-41^{o}35' longitudes in the Northeast of the region. There are no broad plains in this mountainous region. The mountains rise rapidly from the coast. The soil groups in study area were red-yellow podzolic, high mountain meadow, noncalcareous brown forest and brown forest soils (Anonymous, 1990 and 1993). Tea, which is the material of the study, is raised on East Black Sea region red soils (krasnozems) and East Black yellow soils (geltozems) (Hızalan ve ark., 1976).

2.2. Climatical Characteristics of The Study Area

While temperate and rainy weather conditions prevail in summer, mild and snowy weather conditions prevail in winter in this region. According to the long yaear meteorological averages (the last 70 years) (Anonymous, 2006), yearly average temperature, the highest recorded yearly average temperature, the lowest yearly average temperature and average sunshine period were found as 13.8^{o}C, 38.2^{o}C, –7.0^o and 4.14 min/hour/day, respectively. Average relative humidity and average rainfall amount were found as 77% and 2300.4 mm, respectively. Average yearly number of rainy days was recorded as 174.0 days as the average of long years.

2.3. Taking Soil Samples and Preparing Them For Analysis

Soil samples were taken from the 220 tea gardens belonging to 36 tea processing plants during 2nd shoot period (between July 15th and 30th July in 2002) by taking into consideration the tea planted areas and production potentials of these tea gardens. Soil samples taken from at 0-20 cm depth using method developed by Jackson (1962) and were put into polyetylen bags and then labeled. Place coordinates and altitudes of the sampling places were determined using Place Locating System (GPS= Global Positioning System).

Soil samples were spreaded over a clean paper; stone and plant residues were removed, and the samples were air-dried under laboratory conditions and then ground to pass a 2-mm sieve. Sieved samples were preserved in clean paper bags until productivity analyses.

2.4. Productivity Analysis Methods of Soils and Evaluation

Water saturation (%) was determined by adding pure water to the soil until saturation (Richards, 1954). Soil reaction was determined by measuring the pH values of the soil: water solution (1:2.5) by using Orion pH-meter (Sağlam, 1978). While total salinity (%) was determined by measuring electrical conductivity in saturated soil using conductivity equipment (Richards, 1954), lime ($CaC0_3$) content was determined by using Scheibler calcimeter (Çağlar, 1949). Organic matter (%) was determined by using modified Walkley-Black method (Jackson, 1962). The method developed by Bray and Kurtz (1945) was used to determine the organic matter content (%). Available K (K_2O kg/da) content was determined by measuring the amount of K, which can pass to the extract solution prepared by 1 N Ammonium asetate (pH= 7.0), by using flamephotometer (Richard, 1954).

Productivities of the soils were evaluated by comparing soil analysis results with limit values.

Table 1. Minimum, maximum and average values related to the physical and chemical analysis results of tea soils in Rize and Artvin provinces.

Soil Characteristics	Provinces	0-20 cm		
		Min.	Max.	Average
Water saturation (%)	Artvin	59	85	70
	Rize	52	100	69
	General	52	100	69
Total salinity (%)	Artvin	---	0.071	---
	Rize	---	0.340	---
	General	---	0.340	---
pH	Artvin	3.67	5.31	4.26
	Rize	2.80	5.97	3.83
	General	2.80	5.97	3.86
$CaCO_3$ (%)	Artvin	---	---	---
	Rize	---	---	---
	General	---	---	---
Organic matter (%)	Artvin	2.45	10.68	4.91
	Rize	0.66	14.91	5.06
	General	0.66	14.91	5.05
Available phosphorus (kg ha^{-1})	Artvin	13	1013	177
	Rize	2	1450	223
	General	2	1450	220
Available potassium (kg ha^{-1})	Artvin	150	1170	530
	Rize	110	4400	760
	General	110	4400	740

3. RESULTS AND DISCUSSION

Minimum, maximum and average values of the productivity parameters related to 220 soil samples taken from tea gardens found in Rize and Artvin provinces were given in Table 1. Furthermore, soil samples were classified according to the limit values (Table 2).

3.1. Structure Characteristics of Tea Soils

Water saturation levels of tea soils range from 52 to 100% (Table 1). As can be seen in Table 2, 50.9% of the tea soils were clay-loam and 49.1% were clay soils in Rize and Artvin provinces. The distribution of the soil structure groups in these provinces is parallel with the distribution of the soil structure groups in the whole region. The results of this study are in harmony with the results obtained from other studies conducted in the same region. Bayraklı (1975) reported that tea soils in Rize province were clay-loam**.** In a study conducted by Aktaş (1979), while the structure of soils in Artvin province was found between sandy-loam and clay, the structure of those in Rize was found between clay-loam and clay**.** However, in general sense, all of the soils were found to have clay-loam structure. Similar findings were found in another study conducted by Müftüoğlu (1990) in Rize and Artvin provinces.

3.2. Soil Reaction of Tea Soils

As can be seen in Table 1, the pH values of tea soils were ranged from 2.80 to 5.97 in Rize and Artvin provinces. These findings are in harmony with findings of Özuygur et al. (1974), Kacar et al. (1979) and Müftüoğlu (1990).

As can be seen from the pH values of the soils classified according to the limit values reported by Sağlam (1978), 90.7% of the tea soils in Rize and 80.0% of the tea soils in Artvin were in extreme acid group (< pH=4.5) (Table 2). The ratios of soils having ideal pH values (4.50-6.60) for tea production (Tekeli, 1962; Eden, 1976; Tekeli, 1976; Kacar, 1984) were 20.0% in Artvin and 9.3% in Rize. In a study conducted in the same region between 1958 and 1960, the ratios of soil samples having pH<4.50 were the 7.54 % of the total samples in Rize and 0.70% in Artvin (Ülgen, 1961). However, in another study (Sarımehmet, 1987), the ratios of soils found in extreme acid group were 69.06% in Rize and 44.00% in Artvin. In the same study, the soils with ideal pH values (4.50-6.00) had a ratio of 29.93% in Rize and 55.30% in Artvin. Similar results were reported by Müftüoğlu and Sarımehmet (1993a). The ratio of soils with ideal pH values was higher in Artvin compared to Rize. In other words, acidity of soil in Artvin are lower than those in Rize. This difference can be explained by the oldness of the tea soils in Rize compared to those in Artvin. Moreover, the fact that the period of in appropriate fertilization methods used in Artvin is shorter compared to Rize might contribute this difference. Ninety percent of 220 soil samples (198) taken from Rize and Artvin provinces were found to have pH values below 4.50. The ratio of soil samples with ideal pH values (4.50-6.00) was found as 10% (Table 2). Acidification increased dramatically in tea soils during the last two decades and the ratio of soil samples having pH values below 4.50 reached up to 90%. The decrease in soil pH values below 4.50 affects negatively both plant nutrient contents and also the growth of the tea plant.

Table 2. Classification of soil samples taken from tea soils in Rize and Artvin provinces according to the limit values.

Soil Characteristics	Limit value	Evaluation	PROVINCES Artvin Sample counts	%	PROVINCES Rize Sample counts	%	GENERAL Sample counts	%
Water saturation	<30	Sandy	---	---	---	---	---	---
(%)	30-50	Loam	---	---	---	---	---	---
	50-70	Clay-loam	7	46.7	105	51.2	112	50.9
(Ülgen and	70-110	Clay	8	53.3	100	48.8	108	49.1
Yurtsever, 1995)	>110	Haevy clay	---	---	---	---	---	---
Total salinity (%)	0.00-0.15	Nonsalty	15	100	202	98.5	217	98.6
	0.15-0.35	Light-toned salty	---	---	3	1.5	3	1.4
(Ülgen and	0.35-0.65	Moderate salty	---	---	---	---	---	---
Yurtsever, 1995)	>0.65	Excessive salty	---	---	---	---	---	---
pH	<4.50	Extremely acid	12	80.0	186	90.7	198	90.0
	4.50-5.00	Very strong acid	2	13.3	15	7.3	17	7.7
	5.00-5.50	Strong acid	1	6.7	3	1.5	4	1.8
	5.50-6.00	Moderate acid	---	---	1	0.5	1	0.5
	6.00-6.50	Light-toned acid	---	---	---	---	---	---
(Sağlam, 1978)	6.50-7.30	Neutral	---	---	---	---	---	---
Lime (%)	<1.0	Light-toned calcareous	---	---	---	---	---	---
	1.0-5.0	Calcareous	---	---	---	---	---	---
	5.0-15.0	Moderate calcareous	---	---	---	---	---	---
(Ülgen and	15.0-25.0	Excessive calcareous	---	---	---	---	---	---
Yurtsever, 1995)	>25.0	Extremely calcareous	---	---	---	---	---	---
Organic matter	<1.0	Very low	---	---	3	1.5	3	1.3
(%)	1.0-2.0	Low	---	---	17	8.3	17	7.7
	2.0-3.0	Moderate	3	20.0	22	10.7	25	11.4
(Ülgen and	3.0-4.0	Good	4	26.7	34	16.6	38	17.3
Yurtsever, 1995)	>4.0	High	8	53.3	129	62.9	137	62.3
Available phosphorus	0-30	Very low	2	13.3	23	11.2	25	11.4
(P_2O_5 kg ha^{-1})	30-60	Low	6	40.0	22	10.7	28	12.7
	60-90	Moderate	1	6.7	20	9.8	21	9.5
(Ülgen and	90-120	High	1	6.7	15	7.3	16	7.3
Yurtsever, 1995)	>120	Very high	5	33.3	125	61.0	130	59.1
Available potassium	0-200	Low	1	6.7	13	6.3	14	6.4
(K_2O kg ha^{-1})	200-300	Moderate	4	26.6	19	9.3	23	10.5
(Ülgen and	300-400	Adequately	1	6.7	28	13.7	29	13.1
Yurtsever, 1995)	>400	Excessive	9	60.0	145	70.7	154	70.0

Tea plant prefers acidic soils as it does not like calcaerous soils. As mentioned above, tea plant grow best in soils with pH values of 4.50-6.00 and the lowest limit is pH=4.00. Acidity of all soils (including soils with pH<4.00) were shown in Table 3.

The high ratio (66.8%) of soils with pH values below 4.00 in Rize and Artvin is a significant problem in terms of soil productivity (Table 3). According to the Güner (1961), pH should be around 5.3-6.5 in tea soil extracts prepared with water. The same researcher suggested 5.00-5.50 pH values for efficient tea production. Optimum pH values for tea soils reported as 5.6 in East Africa (Wilson, 1969) and 5.00-5.80 in Bangladesh (Karim et al. 1981). Bhattacharyya and Dey (1983) reported that tea plant can grow well in acidic soils. According to these researchers, plant growth can be affected negatively by pH values above 5.70 but it isn't affected so negatively unless pH value is below 3.60.

The most important factor leading to increase in acidification of tea soils is excessive use of ammonium sulfate ($(NH_4)_2SO_4$) for many years. Ammonium sulfate ranks first among the nitrogenous fertilizers in terms of acid formation in soils. Most researchers reported that ammonium sulfate led to increase in soil acidification (Vicar et al., 1963; Harler, 1964; Wijedasa and Fernando, 1971; Sivasubramaniam and Talibudeen, 1972; Karim et al., 1981; Wickremasinghe et al., 1981; Kacar, 1984).

Ammonium sulfate is still being used in high amounts in tea production areas despite of some reports claiming that compose fertilizers have been replaced with ammonium sulfate fertilizers. As a matter of fact, the amount of ammonium sulfate fertilizer (21% N) was 15455 tonnes in Rize province and 738 tonnes in Artvin province according to the records of State Institute of Statistics (SIS) (Anonymous, 2006).

3.3. Calcareous Tea Soils

Tea soils in Rize and Artvin provinces are uncalcareous (Table 1). Ülgen and Yurtsever (1995) suggested that 220 uncalcareous soil samples, which form the research material of their study, can be

Table 3. Classification of the soil samples taken from Rize ve Artvin provinces according to their pH values.

Limit Value	Evaluation	PROVINCES				GENERAL	
		Artvin		Rize			
		Sample Count	%	Sample Count	%	Sample Count	%
<4.00	---	4	26.7	143	69.8	147	66.8
4.00-4.50	Extremely acid	8	53.3	43	20.9	51	23.2
4.50-5.00	Very strong acid	2	13.3	15	7.3	17	7.7
5.00-5.50	Strong acid	1	6.7	3	1.5	4	1.8
5.50-6.00	Moderate acid	---	---	1	0.5	1	0.5
6.00-6.50	Low acid	---	---	---	---	---	---
6.50-7.30	Neutral	---	---	---	---	---	---

classified as less calcareous soils (Table 2). This finding is in parallel to those of Akalan (1968), Bayraklı (1975), Çapan (1979) and Müftüoğlu (1990). This case explains the lower pH values in tea soils. The low calcareousness in tea soils can be explained by the rain intensity, soil structure and soil porosity.

3.4. Organic Matter Content of Tea Soils

Organic matter content of tea soils in Rize and Artvin range from 0.66 to 14.91% (Table 1). Organic matter contents were reported as 0.31-4.34% (Özuygur et al., 1974), 0.49-4.99% (Bayraklı, 1975) and 2.68-16.92% (Kacar et al., 1979) by different researchers. Müftüoğlu (1990), reported that organic matter content varied between 1.86 and 9.30%. The ratio of samples found between 2-6% limit values was 77.3%. The samples higher than 6% limit value consituted 18.2% of the total samples.

Ülgen and Yurtsever (1995) classified tea soils in Rize and Artvin provinces according to their organic matter contents as follows: 1.5% very low, 8.3% low, 10.7% middle, 16.6% good and 62.9% high in Rize and 20.0% moderate, 26.7% good and 53.3% high in Artvin. Out of the total soils in Rize and Artvin provinces (80.0% for Artvin and 79.5% for Rize) 79.6% had organic matter content above 3.0% (Table 2). These figures indicate that the most of the tea soils in Rize and Artvin provinces contain adequate level of organic matter.

Among the organic material sources of tea soils are tea prunings, weeds and farmyard manure. Weeds and tea prunings left in gardens and manure application increase the organic matter contents of tea soils. Furthermore, establishing of tea plantations near the forest lands or within the forests give rise to existence of high organic matter contents in tea soils. This finding is supported by the study of Sarımehmet and Müftüoğlu (1993).

3.5. Phosphorus Content of Tea Soils

Available P contents of tea soils in Rize and Artvin provinces were ranged from 2 to 1450 kg P_2O_5 ha^{-1} (Table 1). In Rize province, while 21.9% of tea soils had a low and extremely low available P content, 78.1% of tea soils had an adequate level of P. In Artvin province, the ratio of soils with low and extremely low P contents is 53.3%. The rest of the soils (46.7%) in this province had adequate P content. These results indicated that tea soils in Artvin had inadequate P levels. On the contrary, most of the tea soils in Rize had excess levels of P. The findings reported by Sarımehmet (1987) and Müftüoğlu and Sarımehmet (1993b) are in harmony with the findings found for tea soils in Rize but not findings in Artvin.

Available P contents were found high and extremely high in 66% of the tea soils in Rize and Artvin provinces (Table 2). This finding is in contradiction with findings obtained from the study which was carried out in this region (Ülgen, 1961). This contradiction might be explained by the fact that compose fertilizers with high P contents were used in high amounts during a period of 45 years. Furthermore, incorrect fertilization applications without taken soil analysis into consideration, can also be another reason for this contradiction.

3.6. Potassium Content of Tea Soils

Available K (K_2O) contents were ranged from 110 to 4400 kg K_2O ha^{-1} in the tea soils of Rize and Artvin provinces (Table 1). In Rize province, 6.3, 9.3, 13.7 and 70.7% of tea soils had low, moderate, adequate and excess available K levels, respectively. The corresponding values were 6.7, 26.6, 6.7 and 60.0% for tea soils in Artvin. Seventy percent of the tea soils in Rize and Artvin provinces had excess levels of available K (Table 2). These findings are in harmony with those of Ülgen (1961), but they are in contradiction with those of Sarımehmet (1987).

In conclusion, this study indicated that tea soils in Rize and Artvin provinces had a clay-loam structure. Organic matter content was found adequate in most of the tea soils. No salt and lime were found in these soils.

In this study, soil acidity was found to be risky in levels. Use of ammonium sulfate fertilizer in addition to compose fertilizer increases soil acidity. For this reason, ammonium sulfate fertilizer should not be used in tea soils with extereme acidity. It can be recommended to use natural materials with high lime contents in tea soils which have extreme acidity, especially during rejuvenation period. Phosphorus and potassium contents were found adequate in tea soils.

This case is not frequent in acidic soils. This is mainly caused by using compose fertilizers in high amounts.

When the productivity paramaters were taken into consideration, tea soils should be analyzed, and fertilization should be done according to the results of these analysis. Furthermore, the farmers of the region should be informed about these results.

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