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Full Length Research Paper

Fertility level determination of the soils in Non Calcic Brown forest great soil group by soil analysis

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This research was carried out to determine the fertility levels of the soils in Bursa Province Non Calcic Brown forest great (NCBFG) soil group. For this purpose, 29 soil samples representing the research area were taken and some physical and chemical properties were determined. The research results showed that the sample soils were mostly sandy loam or sandy clay loam textured, but they had generally moderate texture with an acidic or neutral pH and were noncalcareous and had no signs of salinity problem. The soils' organic matter, total N and exchangeable K levels were insufficient, exchangeable Ca and DTPA+TEA extractable Zn contents were at moderate level, available P, exchangeable Mg and DTPA+TEA extractable Fe, Mn, Cu levels were sufficient. Chemical ffertilizer containing nitrogen and potassium should be applied at suitable forms, time, and methods regarding nitrogen and potassium requirements of the cultivated plant species and plant varieties in these soil types. In addition organic matter contents in these type soils should be increased with an application of organic matter to the soils.

Key words: Non Calcic Brown forest great soil group, soil fertility, nutrient element levels.

INTRODUCTION

Marmara is a highly industrialized region with high population density in Turkey. Bursa as one of the most important city in the region has many technological and agricultural industries; in addition, the location of the city is close to the important consumption centers, which makes transportation easier. With this respect, Bursa is an important production and industrial center as well. Agriculture has retained its importance in Bursa from past till now; however, it is a known fact that agriculture has many crucial problems at present. Approximately 25 percent of the total population of Turkey lives in Marmara Region and Bursa, with its suitable climate and agricultural conditions, plays an important role in meeting food demand of the region; therefore, the agricultural sector of Bursa requires more consideration. Although Bursa has high agricultural potential, land suitable for agriculture is limited in the city.

Approximately 26.5% of the total surface area of the city is suitable for agriculture (I, II, III and IV land capability class), and 69.1% is not (5^{th}, 6^{th}, 7^{th}, 8^{th} land capability class) (Anonymous, 1995). With this respect, due to the limited area suitable for agricultural production, showing necessary consideration for land use and protection is an inevitable obligation. One of the conditions required to increase agricultural potential of the city is to optimize the properties of the agricultural soils for the plants cultivated in city. This could be achieved only by determining the chemical and physical properties of soils, and eliminating unfavorable properties using improvement applications and taking precautions. Land is the fundamental element for agricultural production. Production amount and efficiency per unit area could increase as long as sustainable soils fertility is provided.

Therefore, protection and improvement of sustainable soils fertility bear great importance. Achievement of the desired benefit from agricultural production is closely related to appropriate use of the limited agricultural lands considering their features. In this study, it is aimed to determine the fertility level of the soil pertaining to the

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NCBFG soil group, which comprises the 46.8% of the total surface area of Bursa, located in the Marmara Region of Turkey.

MATERIAL AND METHODS

Geographic location of the study field

Bursa Province is located in Susurluk Basin, south of the Marmara Region, between 39°35'-40°40' N latitude and 28°10'-30°00' E longitude. City with its 1104301 ha surface area is surrounded by Istanbul and Kocaeli to the north, Bilecik to the east, Kütahya in to the south and Balikesir in to the West (Anonymous, 1995).

Climate of the region

Bursa, extending along the southern coastal strip of Marmara Sea, has generally mediterranean climate with dry, hot summer and temperate, rainy winter. Half-continental climate is shown in the interior locations of the region, relatively distant from sea.

Bursa plain shows typical characteristics of the Mediterranean climate; city has balanced annual rainfall distribution, in total 710 mm/year, and annual mean temperature is 14.4°C (Korukcu and Arici, 1986).

Land use status

NCBFG Soil Group which is the subject of the study can be met in any county of Bursa. Primarily wheat and olive and other different culture plants like sunflower, corn and onion are cultivated on the fields of Orhaneli, Büyükorhan, Gemlik, Orhangazi and Iznik where the soil samples were collected.

Collection of soil samples, preparation for analysis and applied analysis

The material used in the study consists of soil samples collected from agricultural fields of NCBFG Soil Group around Bursa Province. Before collecting soil samples, distribution area of the soil was determined studying on 1:100.000-scale soil map, and then soil samples were taken according to Jackson (1962) from 29 different locations in 0-25 cm depth to represent the soil group properly.

Some physical and chemical properties of the soil were analyzed; the texture was determined with the hydrometer method (Gee and Bouder, 1986), pH was measured in the soil-0.01 M $CaCl_2$ suspension in a ratio of 1:2.5 (Richards, 1954), Electric condutivity (ECe) was determined in soil: distilled water suspension in a ratio of 1:2.5 (Rhoades**,**1982). Organic matter content was determined by modified Walkley Black method (Nelson and Sommers, 1982); lime was determined by Scheibler calcimeter (McLean,1982); total nitrogen was determined by Buchi K-437 / K-350 digestion/ distillation unit according to the modified Kjeldahl method (Kacar, 1972); available phosphor was determined by Shimadzu UV 1208 model spectrophotometer according to Olsen method (Olsen et al., 1954); exchangeable cations (Na, K, Ca and Mg) were extracted with ammonium acetate at pH 7.0 (Pratt, 1965) and were determined by the Eppendorf Elex 6361 model Flame photometer and lastly available Fe, Cu, Zn, Mn were extracted with DTPA (0.005M DTPA+0.005M $CaCl_2$+0.1M TEA pH 7.3) and were determined by the Philips PU9200x model Atomic Absorption Spectrophotometer (Lindsay and Norvell, 1978).

RESULTS AND DISCUSSION

Some chemical and physical analysis results of the soils are given in Table 1.

As can be seen in Table 1, sand, silt and clay contents of the soils were found to change between 27.3-79.3, 10-30 and 10.7-50.2%, respectively. It is also determined that soil texture greatly differs as sandy loam, sandy clay loam, clay loam, clay or sandy clay. When the texture class of soil is considered as a whole, it is found that 82.7% of the soils (SL, SCL, CL) are medium-textured and 17.3% (SC, C) are heavy-textured, as is given in Figure 1.

pH levels of the soils of NCBFG Soil Group change between 4.51 and 7.58 (Table 1). Although pH level of the soil samples was found to change between very severe acidic and slightly alkaline according to the classification by Kellog (1952), 58.7% of the soils were acidic and 41.3% were neutral with slightly alkaline pH, as is given in Figure 2.

Electric conductivity of the soils was found to change between 0.18-1.73 $dS.m^{-1}$ (Table 1). This value shows that soils have no salinity problem according to Tüzüner (1990). Similar results were reported by previous studies made in Bursa (Anonymous, 1983; 1995; Başar, 2001). Therefore, all kinds of culture plants can be grown in Bursa without any salinity limitation. Organic matter level of the soils was found to change between 0.52 and 3.28% (Table 1). As can be seen in Figure 3, 82.8% of the soils were found to have low organic matter levels and 17.2% have moderate organic matter levels according to the classification method developed by Ünal and Başkaya (1981). These values show that approximately 80% of soils of NCBFG soil group are sufficient in terms of organic matter. Organic matter has important positive effects on chemical, physical and biological properties of soil. The organic matter level of fertile soils are reported to be between 2 to 5% (Güzel, 1989). Therefore, it is vey important to make cultural applications to increase organic matter level in the soils of the study area. Organic matter level of the soils was reported to change between low and medium levels in a previous study implemented in Bursa (Katkat et al., 1994).

Lime levels of the soil samples collected from study field were found to change between 0.04 and 5.32% (Table 1). As can be seen in Figure 4, according to the classification by Kacar (1994), soils were found to change between noncalcareous and moderate calcareous classes in terms of their lime contents; on the other hand, 86.2% of the soils were determined to be noncalcareous, 6.9% were slightly calcareous and 6.9% were moderate calcareous. These values show that the soils of the study area are generally noncalcareous. The main reason is caused by the properties of rock and parent materials which form the soils. Main rocks serving in the soil formation are andesite, dacite, granite, marl, conglomerate, sand, clay and gravel deposits, majority of which are composed

Table 1. Some physical and chemical analysis results of soils.

Sample no	Districts of collected samples	Cultivated crop	Sand %	Silt %	Clay %	Texture class	pH	ECe, $dS.m^{-1}$	Organic matter, %	$CaCO_3$ %	Total N, %	Available P, mg/ per kg soil	Exchangeable ions, meq/ per 100 g soil				Available microelements, mg/per kg soil			
													Na	K	Ca	Mg	Fe	Mn	Cu	Zn
1	Iznik	Onion	27.3	28.0	44.7	C	7.58	0.45	1.29	0.32	0.06	11.36	0.14	0.26	14.69	4.47	38.98	66.84	1.44	0.78
2	Orhangazi	Olive	39.1	22.0	38.9	CL	6.66	0.40	1.00	0.08	0.08	26.94	0.23	0.92	19.36	8.93	8.71	29.46	3.73	0.92
3	Orhangazi	Olive	59.1	18.0	22.9	SCL	6.68	0.36	1.18	0.08	0.08	23.66	0.08	0.41	15.29	2.82	13.82	22.97	1.72	1.59
4	Orhangazi	Olive	51.8	24.0	24.2	SCL	7.00	0.41	2.15	0.04	0.09	18.40	0.26	0.80	17.68	6.11	5.54	17.53	3.03	1.19
5	Gemlik	Olive	59.1	22.8	18.1	SL	4.51	0.42	2.08	0.21	0.08	15.55	0.13	0.15	13.75	9.52	89.98	80.04	5.02	1.48
6	Gemlik	Olive	53.8	26.5	19.7	SL	6.13	0.41	1.38	0.29	0.08	18.84	0.08	0.25	6.00	1.65	20.09	34.69	1.07	1.50
7	Gemlik	Olive	58.6	14.4	27.0	SCL	6.30	0.47	1.43	0.20	0.08	10.51	0.12	0.26	9.24	3.88	20.77	32.68	1.97	1.38
8	Gemlik	Olive	59.1	22.8	18.1	SL	7.36	0.59	1.52	5.32	0.10	33.08	0.18	0.27	16.87	8.81	10.69	14.43	7.08	0.89
9	Orhaneli	Wheat	55.3	14.0	30.7	SCL	5.69	0.22	0.78	0.12	0.10	7.42	0.30	0.34	15.10	14.10	15.73	37.49	0.16	0.80
10	Orhaneli	Melon	42.3	12.7	45.0	C	6.45	0.36	1.25	0.08	0.10	31.10	0.12	0.50	16.56	26.56	12.50	15.38	0.87	0.65
11	Orhaneli	Sunflower	36.0	20.0	44.0	C	7.35	0.40	1.87	4.13	0.11	13.58	0.19	0.61	21.32	5.17	7.61	28.12	1.84	0.94
12	Orhaneli	Wheat	40.7	26.0	33.3	CL	7.32	0.32	0.92	1.51	0.10	8.76	0.18	0.89	17.64	19.27	2.00	7.41	0.50	0.69
13	Orhaneli	Sunflower	53.3	20.0	26.7	SCL	6.49	0.35	1.22	0.12	0.09	9.62	0.14	0.65	26.29	5.05	5.52	23.14	0.56	0.61
14	Orhaneli	Wheat	45.3	20.0	34.7	SCL	6.93	0.41	2.65	0.20	0.08	41.18	0.12	1.11	18.32	17.98	10.65	20.48	7.41	1.15
15	Orhaneli	Wheat	38.7	28.0	33.3	CL	7.02	0.57	3.28	0.57	0.10	52.57	0.14	1.93	11.72	16.69	9.57	29.63	1.47	1.41
16	Orhaneli	Corn	33.8	16.0	50.2	C	7.35	0.43	1.20	2.58	0.12	2.37	0.16	0.61	25.36	4.00	5.30	7.35	0.95	0.71
17	Orhaneli	Wheat	67.3	16.0	16.7	SL	6.74	0.42	1.09	0.93	0.08	37.68	0.16	0.20	17.27	5.17	7.66	31.20	0.25	0.92
18	Orhaneli	Sunflower	55.3	28.0	16.7	SL	6.09	0.51	1.22	0.16	0.09	43.37	0.09	0.25	8.03	2.00	29.15	26.38	1.54	1.44
19	Orhaneli	Wheat	51.3	20.0	28.7	SCL	5.34	0.21	0.92	0.08	0.10	11.99	0.19	0.21	14.58	9.64	30.07	24.82	1.27	0.52
20	Büyükorhan	Wheat	70.7	18.0	11.3	SL	5.38	0.23	0.95	0.20	0.06	11.04	0.05	0.11	6.55	1.29	15.20	35.42	0.82	2.71
21	Büyükorhan	Wheat	67.3	14.0	18.7	SL	6.23	0.31	1.27	0.20	0.08	26.29	0.07	0.28	12.87	2.59	19.21	31.37	3.06	1.18
22	Büyükorhan	Sunflower	65.8	16.0	18.2	SL	6.35	0.38	0.53	0.20	0.08	6.94	0.10	0.11	9.57	2.70	13.62	15.18	0.35	0.56
23	Büyükorhan	Wheat	71.8	14.0	14.2	SL	5.88	0.21	0.82	0.20	0.06	32.86	0.06	0.26	6.38	1.18	13.95	25.98	0.85	0.73
24	Büyükorhan	Wheat	69.8	16.0	14.2	SL	5.40	0.18	0.73	0.08	0.08	42.06	0.10	0.12	9.13	1.29	16.02	18.02	0.63	0.89
25	Büyükorhan	Corn	72.0	16.0	12.0	SL	5.86	1.73	2.02	0.41	0.06	58.49	0.06	0.62	6.44	1.18	27.32	27.61	0.63	1.91
26	Büyükorhan	Wheat	79.3	10.0	10.7	SL	5.14	0.19	0.52	1.54	0.10	10.73	0.09	0.19	4.84	0.82	13.77	22.22	0.35	0.55
27	Büyükorhan	Sunflower	69.3	20.0	10.7	SL	4.70	0.43	0.56	0.08	0.08	11.83	0.08	0.21	4.68	0.82	24.29	24.40	0.75	0.51
28	Orhaneli	Wheat	42.7	30.0	27.3	CL	6.54	0.62	1.02	0.29	0.10	14.36	0.10	0.29	14.30	4.00	9.97	30.89	1.18	0.67
29	Orhaneli	Wheat	45.3	16.0	38.7	SC	7.44	0.34	1.50	3.86	0.11	3.63	0.18	0.68	21.10	6.35	8.38	11.53	2.45	2.17

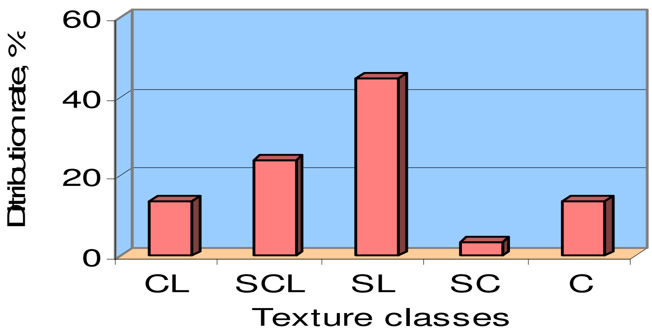

Figure 1. Texture classes distribution of soils.

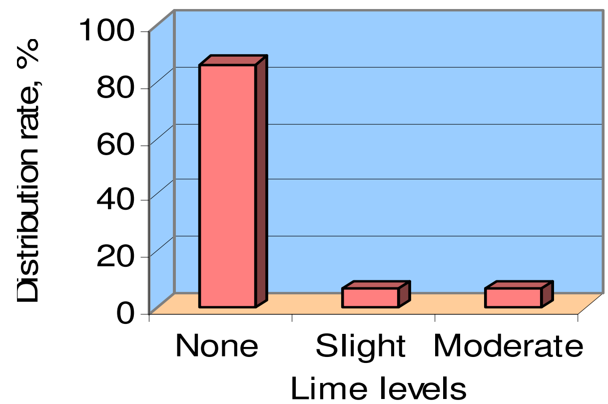

Figure 4. Distribution of lime levels of soils

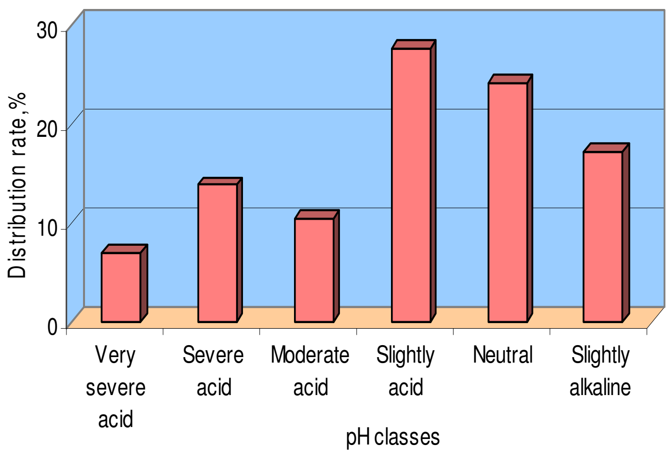

Figure 2. pH classes distribution of soils.

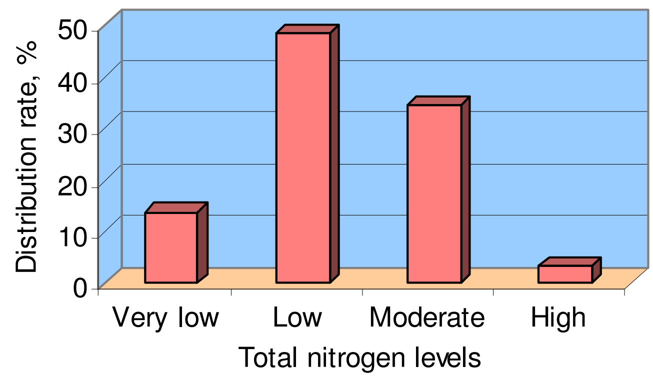

Figure 5. Total nitrogen levels of soils.

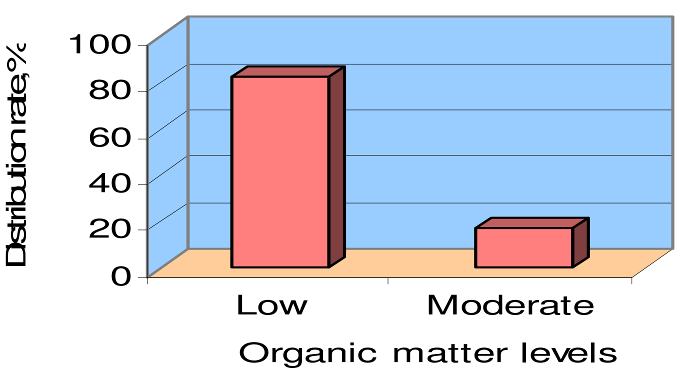

Figure 3. Distribution of organic matter levels of soils.

of acidic rocks with zero lime content. In addition, the texture class of large majority (82.7%) of the soils is moderate texture class and annual rainfall is 710 mm or above in Bursa; therefore, lime could easily be washed from upper to lower layer of the soils. Large majority of the soils are noncalcareous (86.2% of soils) and have acidic pH (58.7% of the soils); therefore, lime addition may be required considering the pH demand of the culture plants that is or will be cultivated in the region.

Total nitrogen level of the soils was found to change between 0.06 and 0.12% (Table 1). As can be seen in Figure 5, according to the classification method developed by Loue (1968), soils of NCBFG Soil Group were found to change between very low and high levels in terms of nitrogen content; on the other hand, 13.8% of the soils contain very low level of nitrogen, 48.3% contain low, 34.5% contain moderate and 3.4% contain high level of nitrogen. These values show that approximately 60% of the soils contain very low and low level of nitrogen; in addition, 35% contain moderate level of nitrogen, which is accepted as critical level. Therefore, soil could be insufficient in meeting the nitrogen demand of plants. Low nitrogen level of the soils is caused by longlasting inadequate use of organic fertilizer. This opinion is supported by the fact that 82.8% of the soils of the study area contain low level nitrogen. In addition, 82.7% of the soils are in medium texture class, which shows that chemical nitrogen fertilizers could easily be washed from soil surface with rain or irrigation. Nitrogen fertilizer should be applied considering the needs of the plants.

However, special consideration special consideration should be given to application time, suitable nitrogen

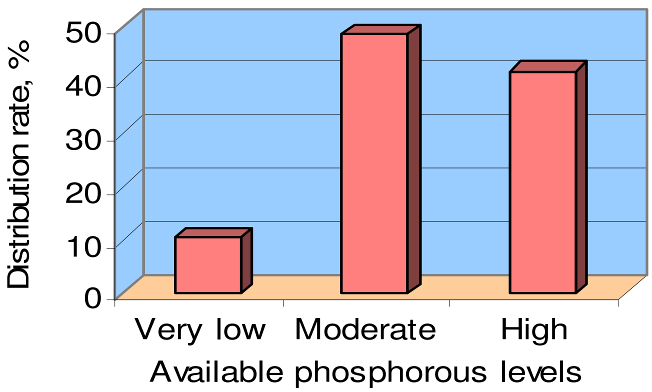

Figure 6. Available phosphorous levels of soils.

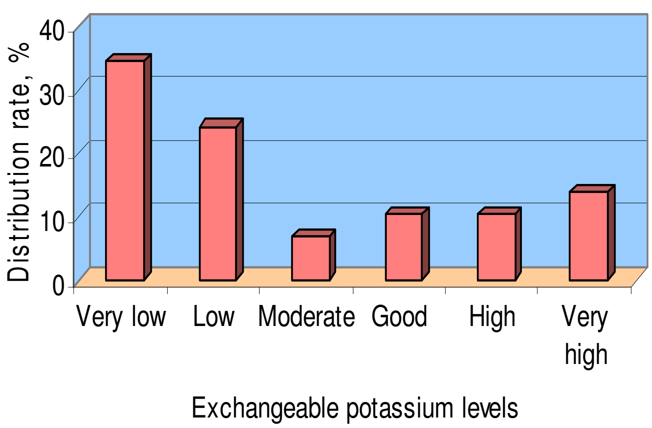

Figure 7. Exchangeable potassium levels of soils.

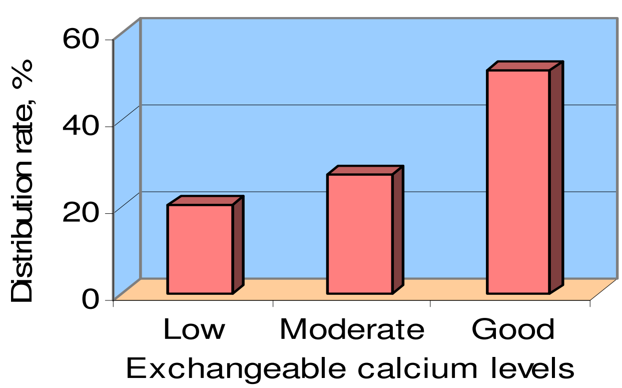

Figure 8. Exchangeable calcium levels of soils.

fertilizer form and application method. Soil was reported to be inadequate in terms of nitrogen content by a previous study made on some chemical and physical properties of the soil in Bursa (Katkat et al., 1988).

Phosphorous (P) level of the subject soils examined in the study was found to change between 2.37 and 58.49 mg P/per kg soil (Table 1). As can be seen in Figure 6, according to the classification method developed by Olsen and Dean (1965), 10.3% of the soils contain very low phosphorous level, 48.3% contain moderate and 41.4% contain high phosphorous level. Available phosphorous level of the soils is adequate; however, 58.6% of the soils contain very low or moderate phosphorous levels, which increases the possibility of phosphorous deficiency depending on the phosphorous needs of the plants. Therefore, considering phosphorous needs of the cultivated plants, necessary phosphorous fertilization should be applied. It was reported in a previous study made in Bursa that 78.19% of the soils contain medium or high levels of phosphorous (Başar, 2001). And some other studies reported that available phosphorous content of the soils is adequate (Tümsavaş, 2002, 2003).

Exchangeable sodium level of the soils of the study area was found to change between 0.05 and 0.30 meq Na^+/per 100 g soil (Table 1). Exchangeble sodium level of the soils was determined to be below 15%. Therefore, soils pertaining to NCBFG Soil Group have no problem in terms of sodium.

Exchangeable potassium level of NCBFG Soil Group was found to change between 0.11 and 1.93 meq K^+/per 100 g soil (Table 1). As can be seen in Figure 7, according to the classification method developed by Pizer (1967), soils were found to change between very low and very high levels of exchangeable potassium; on the other hand, 58.7% of the soils were found to contain very low and low levels of potassium, 6.9% contain moderate and 34.4% contain good, high and very high levels of exchangeable potassium. These values show that soils do not have adequate levels of exchangeable potassium. Since potassium affects quality properties such as color, taste and aroma of the crop, necessary amount of potassium fertilization should be applied to cultivated plants.. Previous studies made in the region reported that exchangeable potassium content of the soils is usually adequate and there is no important problem in this respect (Katkat et al., 1988; 1994).

Exchangeable calcium level of the soils of the study area was found to change between 4.68 and 45.05 meq Ca^{++}/per 100 g soil (Table 1). As can be seen in Figure 8, according to the classification method developed by Loue (1968), soils varied between low and good levels in terms of their exchangeable calcium content; on the other hand, 20.7% of the soils were found to contain low levels of calcium, 27.6% contain moderate and 51.7% contain good levels of calcium. Exchangeable calcium content of the soil is adequate; however, since 50% of the soils contain low or moderate levels of calcium, calcium deficiency risk increases depending on the calcium demands of the cultivated plants. Culture plants like tomato and strawberry cultivated in the region require high levels of calcium; in that case, calcium fertilization could be applied. Therefore, plants should be observed

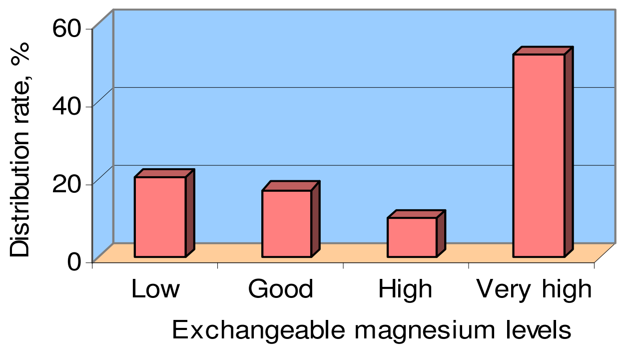

Figure 9. Exchangeable magnesium levels of soils.

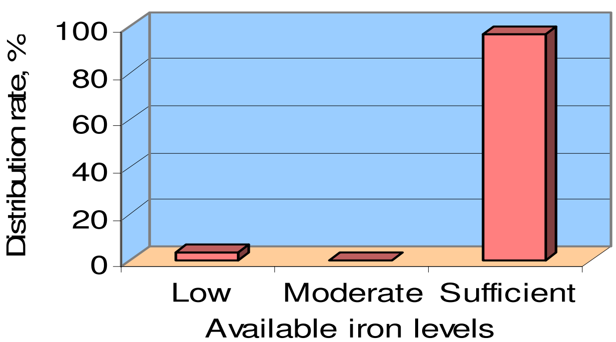

Figure 10. Available iron levels of soils.

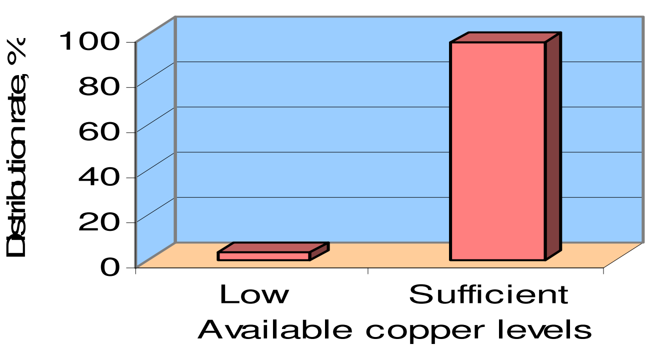

Figure 11. Available copper levels of soils.

for their calcium needs, and calcium reach materials such as limestone ($CaCO_3$), dolomite ($CaMg(CO_3)_2$, calcium-oxide (CaO), calcium hydroxide and jips ($CaSO_4.2H_2O$) which are cheap and easily obtainable materials should be applied to soil.

Exchangeable magnesium level of the soils of the study area was found to change between 0.82 and 26.56 meq Mg^{++}/per 100 g soil (Table 1). As can be seen in Figure 9, according to the classification method developed by Loue (1968), 20.7% of the soils were found low in terms of exchangeable magnesium levels and the rest (79.3%) were found to contain good, high and very high levels of

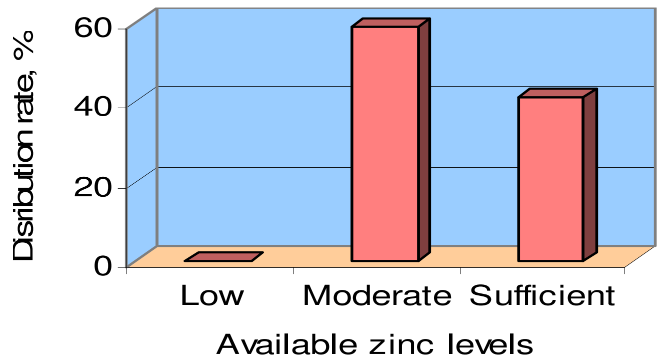

Figure 12. Available zinc levels of soils.

magnesium. This situation shows that the soils examined in the study contain adequate exchangeable magnesium. Available Iron (Fe) level of the soils, which was extracted using DTP-TEA was found to change between 2.00 and 89.98 mg Fe/per kg soil (Table 1). As can be seen in Figure 10, according to the classification method developed by Follet and Lindsay (1970), 3.4% of the soils were low in terms of available iron level and the rest (96.6%) were found to contain adequate iron level. These values show that soils of NCBFG soil group are quite sufficient in terms of available iron level. In a previous study implemented in the soils of Bursa Province to determine the levels of Fe, Zn, Mn and Cu extracted using DTPA-TEA solution, some soils in the region were found insufficient in terms of available iron (Fe) content (Eyüpoğlu et al., 1996). However, other studies report that Non Calcic Brown and Vertisol great soil groups were sufficient in terms of useful available iron (Fe) content (Tümsavaş, 2003; Tümsavaş and Çelik, 2005).

Available manganese (Mn) level of the soils of the study area was found to change between 7.35 and 80.04 mg Mn/per kg soil and available copper (Cu) level between 0.16 and 7.41 $mg.kg^{-1}$ (Table 1). According to the classification method developed by Follet and Lindsay (1970), 100% of the soils were sufficient in terms of manganese content; however, 3.4% of the soils were found low and the rest (96.6%) were sufficient in terms of copper content as shown in Figure 11.

Available zinc (Zn) content of the soils, which was extracted using DTPA-TEA, was found to change between 0.51 and 2.71 mg Zn/per kg soil (Table 1). As can be seen in Figure 12, according to the classification method developed by Follet and Lindsay (1970), 58.6% of the soils were found moderate and 41.4% were sufficient level in terms of available zinc content. Available zinc level of the soils is sufficient under the present conditions; however, majority of the soils (58.6%) contain moderate level of zinc, which increases the risk for zinc deficiency depending on the zinc needs of the plants cultivated in the region. Therefore, cultivated plants should be observed in terms of their zinc needs, and zinc (Zn) fertilizers should be applied if necessary.

In conclusion, agricultural soils of NCBFG soil group are composed dominantly of sandy loam and sandy clay loam with moderate texture class and have acidic and neutral or slightly alkaline pH. The soils have no salinity problem and are fairly low level in terms of organic matter and also noncalcareous. Since the majority of the soils are noncalcareous (86.2% of the soils) and have acidic pH (58.7% of the soils), lime addition should be applied to create suitable conditions considering the pH needs of the culture plants which are or will be cultivated on these soils. Total nitrogen (N) and exchangeable potassium levels of the soils of study area are insufficient; however, exchangeable magnesium (Mg), available iron (Fe), manganese (Mn) and copper (Cu) levels are highly sufficient. Organic fertilizers have not been used adequately for years, which is reason for the insufficient nitrogen in the soil. In this respect, low levels of organic matter content in approximately 80% of the soils justify this view. For this reason, there are important advantages in the realization of agricultural applications to increase organic matter content of the soils. In addition, chemical fertilizers should be applied to prevent possible damage caused by insufficient nitrogen (N) and potassium (K) depending on the needs of the plants. However, special consideration should be given to application time, suitable nitrogen fertilizer form and application method.

Although exchangeable calcium (Ca), available phosphor (P) and zinc (Zn) levels are adequate in the soils of the study area under present conditions, the amounts of these mentioned elements change between very low and moderate levels for the half of the soils, which indicates that calcium, phosphor and zinc concentrations may decrease below the limits required for plants cultivated in the region and deficiency signs may appear. Since the soils are mostly medium-textured, especially calcium and zinc, plant nutrition elements increase the washing risk because these elements could be washed by water from the upper to deeper soil layers. Therefore, plants cultivated in the study area should be observed carefully for their calcium and zinc needs, and fertilizers containing calcium and zinc should be applied, if necessary.

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