


Determination of Nutritional Status of Olive (*Olea europaea* L.) Trees Grown in Izmir and Mugla Province in Terms of Boron and The Other Microelements with Soil and Leaf Analyzes


İzmir ve Muğla İllerinde Yetiştirilen Zeytin (*Olea europaea* L.) Ağaçlarının Bor ve Mikro Elementler Yönünden Beslenme Durumunun Yaprak ve Toprak Analizleri ile Belirlenmesi


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Abstract


This study was conducted to determine the nutritional status of olive cultivated land and olive plant in Izmir and Mugla province in terms of boron and other elements. For this purpose, 254 soil samples (0-30 cm depth) and 254 leaf samples were taken simultaneously with GPS coordinates from the olive production areas and analyzed (125 gardens in Datca, Koycegiz, Milas, Ula, Seydikemer districts of Mugla province / 129 gardens in Aliaga, Bayindir, Bergama, Dikili, Foca, Karaburun, Kemalpaşa, Menderes, Menemen, Odemiş, Seferihisar, Selcuk, Tire, Torbali and Urla district of Izmir province). In the soil samples texture, pH, EC, lime, organic matter, extractable boron, iron, copper, zinc and manganese analysis were done. In the leaf samples total boron, iron, copper, zinc and manganese content were determined. According to the analysis results, the nutritional studies of olive were determined in term of boron and other elements. According to the results of the research, boron contents of the research areas soils ranged between 0.20 and 5.24 mg kg⁻¹ and the average level was determined as 1.21 mg kg⁻¹. In the boron content distribution of the soils in the research area 13.78% is low, 76.38% is sufficient, 9.45% is more and 0.39% is too high. Boron contents of olive leaves ranged between 8.66 and 29.33 mg kg⁻¹ and the average level was determined as 8.66 mg kg⁻¹. In the boron content distribution of the leaves in the research area 85.04% is low, 14.96% is sufficient. Based on the B contents of all soil and leaf samples it was interesting to note that


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although 85.83% of the soils have sufficient boron, 85.04% of the leaves show boron deficiency, indicating that boron nutritional problems are experienced. Also according to the results of analysis, it was determined that there were no nutritional problems in terms of iron, and that there were serious nutritional problems in terms of boron and zinc. It was determined that nutritional problems in term of manganese and copper slightly. As with all plant species, fertilization programs for olive plant should be established according to soil and leaf analysis result. According to the results of analysis, it is important to give the deficient macro and micronutrients in addition to phosphorus, nitrogen and potassium fertilizers which will be given with basic fertilization.

Keywords: Boron, Plant nutrition, Olive production, Mineral status

Özet

Bu çalışma, İzmir ve Muğla ilerinde zeytin yetiştiriciliği yapılan toprakların ve zeytin bitkisinin bor ve diğer elementler yönünden beslenme durumunun belirlenmesi amacıyla yürütülmüştür. Bu amaçla 254 adet toprak (0-30 cm) ve yaprak örneği GPS koordinatlı olarak eş zamanlı alınmış ve analiz edilmiştir (Muğla ilinde: 125 bahçe Dataca, Köyceğiz, Milas, Ula, Seydikemer/İzmir ilinde: 129 bahçe Aliağa, Bayındır, Bergama, Dikili, Foça, Karaburun, Kemalpaşa, Menderes, Menemen, Ödemiş, Seferihisar, Selçuk, Tire, Torbalı, Urla). Toprak örneklerinde; tekstür, pH, EC, kireç, organik madde, ekstrakte edilebilir B, Fe, Cu, Zn, Mn; yaprak örneklerinde ise toplam B, Fe, Zn, Mn, Cu analizleri yapılmıştır. Araştırma sonuçlarına göre, toprakların bor içerikleri 0.20 ve 5.24 mg kg⁻¹ arasında değişmiş, ortalama bor içeriği ise 1.21 mg kg⁻¹ olarak belirlenmiştir. Araştırma alanı toprakları ekstrakte edilebilir B içerikleri bakımından incelendiğinde %13.78'i az, %76.38'i yeterli, %9.45'i fazla ve %0.39'u çok fazla sınıfında yer almıştır. Yaprakların bor içerikleri 8.66 ve 29.33 mg kg⁻¹ arasında değişmiş, ortalama bor içeriği ise 8.66 mg kg⁻¹ olarak belirlenmiştir. Araştırma alanı yaprakların bor içerikleri dağılımı ise %85.04'ü az, %14.96'sı yeterli olarak belirlenmiştir. Toprak ve yaprakların bor içerikleri birlikte değerlendirildiğinde toprakların %85.83'nün yeterli bor içermesine rağmen yaprakların %85.04'nün yetersiz bor içermesi ciddi bor beslenme sorunlarının yaşandığını göstermektedir. Analiz sonuçlarına göre, demir bakımından beslenme sorunlarının olmadığı, çinko bakımından ciddi, mangan ve bakır bakımından ise azda olsa beslenme sorunlarının yaşandığı görülmektedir. Tüm bitki türlerinde olduğu gibi zeytin bitkisi için gübreleme programları toprak ve yaprak analiz sonuçlarına göre oluşturulmalıdır. Analiz sonuçlarına göre, temel gübreleme ile verilecek fosfor, azot ve potasyum gübrelere ek olarak mikro besin maddelerinin verilmesi önemlidir.

Anahtar Kelimeler: Bor, Bitki besleme, Zeytin üretimi, Mineral durumu

1. Introduction

Hatay-Maras-Mardin strip is known that native country of olive (*Olea europaea L.*). Olive has wide production areas on the Aegean and Mediterranean coasts and this reason, it carries a distinct economic importance for Turkey and Mediterranean basin countries. Demand of olives increases considerably because of the fruit processed in different ways and the positive effects of oil on human nutrition (Deliboran et al., 2019; 2019a).

According to 2013 data, World crude olive production is 20.3 millions tons in 10.2 million ha area. Spain is the leading country with 7.9 millions tons of production and Italy, Greece and Turkey are followed the Spain with 2.9; 2.0 and 1.7 million ton olive production, respectively (Deliboran et al., 2019).

Olive are generally grown by conventional methods in the Marmara, Aegean, Mediterranean, Southeastern Anatolia and the Black Sea Region of Turkey. There are about 169 million olive trees in Turkey, and 17% of the new plant has not yet reached the yield situation in the garden. Considering the presence of trees, the Aegean Region takes the first place with 83.030.213 trees, followed by the Mediterranean (40.418.083), Marmara (29.754.049), Southeast Anatolia Region (15.254.670) and the Black Sea Region, respectively (Deliboran et al., 2019). The region where olive production is most intense (75%) is being cultivated in many different topography, soil groups and microclimate fields in Canakkale, Balikesir, Izmir, Manisa, Aydin and Mugla in the Aegean Region. There are 24.138.088 table varieties in 997.871 da area, and 58.892.125 oil varieties in 3.417.017 da area, and most of the production is made with oil varieties (Anonymous, 2014).

Based on the presence of trees, it is understood that Mugla and Izmir province 44% of the olive tree presence in the Aegean Region. It has been observed that causes of low yield in the Aegean Region are periodicity, climate events and cultural practise mistakes. On the other hand, it is determined in the research that fertilization is done well and scientific principles are not followed. As a result, average yield of oil varieties decreased to 11 kg tree⁻¹. The aim of the olive farmer should be to increase the yield and quality of olive and to reduce production fluctuations arising from periodicity (Anonymous, 2011); (Deliboran et al., 2019; 2019a); (Doran and Aydın, 1999).

In recent years, as the reason for the increase of olive production in Turkey can be listed that i) improvement of climate conditions, ii) planting of new olive sapling, iii) studies on encouraging olive production. Progress in parallel with positive developments of olive production; these are i) modernization of olive extraction facilities, ii) increased capacity, iii) because of this reason, increase of olive oil quantity and quality (Deliboran et al., 2019; 2019a; 2019b). According to Olive Oil Sector Report (2013); while the average olive oil production was 61 thousand tons before the 1995/96 season, it doubled in the following twelve seasons (1996/1997–2007/2008) to an average of 120 thousand tons. Olive plants which are very important for Turkey's economy, it is more important for the province of farmers and the economy will be carried out the research. In this respect, the studies to be carried out in the region and increasing the yield and especially the quality (nutritional value) of olives will make a major contribution to the national and regional economy.

Especially the trend of the world olive oil consumption in recent years is that the olive oil is produced under high quality and controlled conditions as much as possible. Olive oil producers will need to turn to high quality and qualified olive oil production in order to maintain their current market shares and enter new markets. In the world trade, the importance of olive oil is expected to increase due to the increasing awareness of health and the demand to food produced by controlled means. Increased income and rising living standards will lead to new markets for olive oil. Indeed, world olive oil consumption was 30.611 million tons, consumption of Turkey was 147.800 tonnes, per capitata consumption was 2 kg in 2014 (Anonymous, 2014). Turkey is among the net oil-exporting countries. The highest amount of olive oil exports was 931 tons and 291 million dollars in 2004/05 season. The increase in the demand for olive oil in the world have contributed to the emergence of new export markets for Turkey. In 2012, olive oil was exported to 101 countries. The highest olive oil export was realized to USA with 17 million dollars by years 2012, This was followed by Saudi Arabia with \$ 13 million and Japan with \$ 7.3 million. Exports to these three countries was accounted for 45% of Turkey total exports (Olive Oil Sector Report, 2013). Olive/olive oil production and export is important contribution to the national economy with its place in export. About 400.000 families earn a livelihood from olive farming in Turkey.

Even with the current production amount, the contribution of olive and olive oil to the national economy is not underestimated. However, Turkey is behind some countries in term of quality and exports because of the product obtained from unit area. This is an indication that olive and olive oil production has not reached the desired level yet (Deliboran et al., 2019a). The most appropriate solution to increase agricultural production is to increase the amount of product taken from the unit area. This can only be achieved by balanced fertilization. For this reason, the existing nutritional problems of the production areas should be identified well.

In recent studies, it has been revealed that nutritional problems related to micronutrients are common in the soil of the region. In the survey studies done to determine their nutritional status of Turkey olive groves, it was determined that most deficiency of boron (B), zinc (Zn), potassium (K) and nitrogen (N), respectively (Dikmelik, 1989); (Aksalman et al., 1993); (Doran and Aydin, 1999); Deliboran et al., 2019; 2019a, 2019b). Although micronutrients are taken in small amounts by plants, they have important functions in plant metabolism. B, which is one of the micronutrients. B is one of the absolute micronutrients necessary for plants and its deficiency and toxicity symptoms are common. For this reason, the role of B in plant nutrition is gain a very careful position (Deliboran et al., 2019a).

As a result, increasing olive/olive oil yield and quality is importance for the regional farmer and ultimately for the country's economy. This will only be possible with the determination of the nutritional problems of the existing production areas and fertilization studies according to the results to be obtained. With this study, it was aimed to examine the boron nutritional status of olive groves in Izmir and Mugla province with soil-leaf analysis, to compare the obtained results with reference values and to identify the problems that arise due to various reasons.

2. Materials and Methods

2.1. Research area

The fields of olive growing in Izmir and Mugla province constitute the material of the study. In November and December 2015, soil and plant samples were taken simultaneously from 254 different olive groves to represent the region. The number of soil and plant samples and production areas are given in Table 1.

Table 1. The number and distribution of sample

Countries		Soil Samples	Distribution of Soil Samples	Leaf Samples	Distribution of Leaf Samples
		(piece)	(%)	(piece)	(%)
Mugla	Datca	2	1.60	2	1.60
	Koycegiz	4	3.20	4	3.20
	Milas	80	64.00	80	64.00
	Ula	9	7.20	9	7.20
	Seydikemer	30	24.00	30	24.00
Izmir	Aliaga	9	6.98	9	6.98
	Bayindir	23	17.83	23	17.83
	Bergama	12	9.30	12	9.30
	Dikili	8	6.20	8	6.20
	Foca	2	1.55	2	1.55
	Karaburun	4	3.10	4	3.10
	Kemalpasa	10	7.75	10	7.75
	Menderes	9	6.98	9	6.98
	Menemen	3	2.33	3	2.33
	Odemis	8	6.20	8	6.20

Seferihisar	7	5.43	7	5.43
Selcuk	10	7.75	10	7.75
Tire	5	3.88	5	3.88
Torbali	12	9.30	12	9.30
Urla	7	5.42	7	5.42
Total	254	100.00	254	100.00

2.2. Sampling method, selection of sampling sites and taking soil samples

In November-December, the leaf samples were plucked from the one-year branches coming from the middle part of the tree crown with stems including a total 50 piece. The leaf sample were taken different trees to represent the garden from 4 different sides of the trees, namely East, South, West and North. Soil samples were taken simultaneously from 0-30 cm depth. Sampling was carried out in GPS coordinates.

2.3. Preparation of samples for laboratory analysis

Soil samples brought to the laboratory, stone and plant particles were extracted and spread on clean packaging paper and allowed to air dry. The dried soils were forged with wooden mallets, passed through a 2 mm steel sieve, put into glass jars, labeled and made ready for analysis. Leaf samples brought to the laboratory were first washed with tap water, then with 0.1 N HCl and deionized water 2 times, then the excess water was taken with drying paper and dried in air circulation drying cabinet at 70 °C for 48 hours (until constant weight) and milled in tungsten coated mill prepared for analysis.

2.4. Soil analyzes

Texture (sand, silt and clay fractions of soil samples) were determined by hydrometer method, according to Tuzuner (1990). Soil reaction (pH) was determined by pH meter from 1: 2.5 ratio of soil + pure water mixture, according to Tuzuner (1990). Electrical conductivity (ECx106 $\mu\text{mhos cm}^{-1}$) was measured using electrical permeability instrument from 1:5 ratio of soil: pure water mixture, according to Tuzuner (1990). Lime ($\text{CaCO}_3\%$) was determined as volumetric by Scheibler calcimetry, according to Tuzuner (1990). Organic matter (OM) (%) was determined by Walkey-Black method according to Tuzuner (1990). Available calcium (Ca), magnesium (Mg), sodium (Na), potassium (K) were determined by ICP-OES (Varian-Vista) from extracted with 1 N ammonium acetate (pH 7.0) as reported by Tuzuner (1990). Available phosphorus (P) was determined by Olsen (1972)'s NaHCO_3 method (Kacar, 1982). Available iron (Fe), Zn, manganese (Mn) and copper (Cu) were determined by ICP-OES (Varian-Vista) after extraction with 0.005 M DTPA + 0.01 M CaCl_2 + 0.1 M TEA (pH 7.3) according to Lindsay and Norvell (1978) (Kacar, 1982). Available B was determined by the hot water extraction method according to Gupta (1967), and Gestring and Soltanpour (1981).

2.5. Plant analysis

After the samples are brought to the laboratory, the samples were washed with first the tap water, 0.1 N HCl and 2 times deionized water, respectively. Then the excess water is taken with drying paper. The samples were made ready for analysis by drying in air circulating cabinet at 70 °C for 48 hours (until constant weight) and grinded in tungsten coated mill. 0.3 g of the milled plant parts were taken and dissolved in 5 ml 65% HNO_3 and 3 ml dH_2O in a closed system microwave device (Cem Mars Xpress), the final volumes were completed to 25 ml with ultra deionized water and filtered through blue band filter paper. The concentration of B and other nutrients in filtrates was determined by ICP-OES (Varian, Vista). Measurements of mineral concentrations were checked with certified values of the relevant minerals in the reference plant materials obtained from the National Institute of Standards and Technology (NIST, Gaithersburg, MD, USA).

3. Results and Discussion

3.1. Some physical and chemical properties of soils

3.1.1. Texture

Sand, clay, silt content of the soils are ranged between 19.52-83.68%, 0-58.88%; 2.72-65.76% respectively (Table 2). According to Anonymus (1951) 39.76% of the soil is sandy loamy (SL), 14.96% is loamy (L), 17.72% is clayey loamy (CL), 15.75% is sandy clayed loam (SCL), 9.06% is clayed (C) and 2.36% is sandy clayed (SC) (Table 4). Olive shows better development in well-ventilated, low ground water, L, CL, SL soils (Kacar and Katkat, 1999), generally in lightly structured soils (34-65% sand, 24-28% clay) (Ozbek, 1981); (Mengel and Kirkby, 1987). Considering that the differently structured soils from sandy to clay are suitable for olive cultivation (Colakoglu, 1985) and considering the texture classes in the study as a whole, it is understood that most of them are light bodied and suitable for olive farming. In some studies conducted to determine the nutritional status of olives, it has been determined that soil is clay-loam in the province of Izmir (Aydogdu, 2011); loam and clay-loam in Gemlik region (Uysal et al., 2011), clay-loam, loam and sand in Armutlu peninsula (Uysal et al., 2016); loam and clay-loam on the Kapidag Peninsula (Saglam et al., 2008); loamy and clayey loam structure in the Derik region (Doran et al., 2008).

Table 2. The lowest, highest and average values of structure, pH, EC, lime and organic matter of soil samples

Values	Structer			pH	EC (dS m ⁻¹)	Lime (%)	OM
	Sand	Clay (%)	Silt				
Lowest	19.52	0.00	2.72	5.12	0.05	1.16	0.86
Highest	83.68	58.88	65.76	8.36	1.16	74.50	5.74
Average	52.26	23.14	24.44	7.14	0.35	14.50	2.24
Basıklık	-0.94354	-0.55736	1.329273	0.017368	0.621149	2.203631	1.802974
Çarpıklık	-0.07611	0.339876	0.666836	-1.06018	0.950915	1.816453	1.118681
Ortanca	52.4	20.32	22.72	7.465	0.3	4.12	2.11
Stds	14.32469	11.3997	9.112166	0.7307	0.204119	19.98332	0.807014
Varyans	205.1968	129.9531	83.03157	0.533923	0.041665	399.3332	0.651271
DK	27.40962	49.25636	37.28309	10.22465	58.14964	137.7925	36.0141

3.1.2. pH

The pH of the soils ranged from 5.12 to 8.36 (Table 2). Within the total area, 50.39% of the soil is mild alkaline, 22.83% is neutral, 22.44% is med acid, 3.94% is alkaline (Table 4). Olive tree can be grown in a wide soil reaction (Ozbek, 1981); (Llamas, 1984); (Hartmann and Lilleland, 1966). Considering that it develops well in slightly acidic (pH 6.5) and slightly alkaline (pH 7.8) soils, and 50.39% of the research area soils are slightly alkaline and 22.83% are neutral, it is understood that the soils of the region is suitable for olive farming in this respect. In order to reduce the pH in the alkaline reaction soils (1.55%), powder sulfur should be applied in the fall, preferably with farm manure or physiological acid fertilizers should be used. In some studies conducted to determine the nutritional status of olives, soils are determined that neutral and medium alkaline in the Western Anatolian Region; a neutral and slightly alkaline in the Gemlik region (Uysal et al., 2011), acid in the Armutlu peninsula (Uysal et al., 2016); light and medium acid in Kapidag peninsula (Saglam et al., 2008); slightly alkaline in the Izmir (Aydogdu, 2011), Derik (Doran et al., 2008) and Urfa region (Soylemez et al., 2017).

Table 3. The lowest, highest and average value of extractable B, Fe, Zn, Cu and Mn

Values	B	Fe	Cu	Zn	Mn
	(mg kg ⁻¹)				
Lowest	0.20	1.62	0.13	0.09	0.96
Highest	5.24	92.81	20.60	9.15	78.60
Average	1.22	17.70	2.40	1.46	16.71
Kurtosis	6.71	2.95	15.13	7.08	5.23

Skewness	1.72	1.79	3.42	2.27	2.02
Median	1.14	9.63	1.70	9.47	16.71
Stds	0.67	17.09	2.59	1.46	14.32
Variance	0.45	291.91	6.69	1.03	12.13
DK	55.47	96.54	107.96	1.32	147.25

3.1.3. EC

EC values ranged from 0.05 to 1.16 dS m⁻¹ (Table 2). According to Anonymous (1951), 100% of the soils were included in the saltless class (Table 4). It can be said that the soil of the research area will not be a problem for olive cultivation in terms of salinity. Olive trees are moderately resistant to salt (Ozbek, 1981); (Llamas, 1984). Kasirga (2009) found that the point where Na-origin salinity damage starts for the Gemlik variety is between 4.0 dS m⁻¹ and 8.0 dS m⁻¹. In some studies conducted to determine the nutritional status of olives, all the soils are in the salt-free class in the Western Anatolian Region (Turan et al., 2013), Izmir (Aydogdu, 2011) and Urfa provinces (Soylemez et al., 2017), in the Kapidag peninsula (Saglam et al., 2008), 96% of olive groves of Armutlu peninsula are in the salt-free class (Uysal et al., 2016). The soluble salt content of olive groves ranged from 0.28% to 0.40% and was mostly determined in the less salty class in the Derik region (Doran et al., 2008).

Table 4. The status and distribution of soils in terms of pH, EC, lime and organic matter

Nutrient	Limits	Evaluation	Number of sample	Distribution
			(piece)	(%)
Structer (Anonymous, 1951)		Sandy Loamy	101	39.76
		Loamy (L)	38	14.96
		Sandy Clayed Loam (SCL)	40	15.75
		Clayed (C)	23	9.06
		Sandy Clayed (SC)	6	2.36
		Clayey Loamy(CL)	45	17.72
		Loam Sandy (LS)	1	0.39
pH	<5.1	Strong acid	1	0.39
	5.1-6.6	Mid acid	57	22.44
	6.6-7.3	Neutral	58	22.83
	7.4-7.9	Mild alkaline	128	50.39
	7.9-8.5	Alkaline	10	3.94
	>8.5	Strong alkaline	0	0.00
EC (dS m ⁻¹) (Anonymous, 1951)	<2.5	Saltless	254	100.00
	2.6-4.5	Brackish	0	0.00
	4.6-6.9	Mesosaline	0	0.00
	7.0-10	High saline	0	0.00
	>10	Extreme saline	0	0.00

Lime (%) (Evliya, 1964)	<2.5	Low	94	37.01
	2.6-5.1	Limy	41	16.14
	5.1-10.1	High	33	12.99
	10.1-20.0	Very high	27	10.63
	>20.0	Extreme	59	23.23
OM (%) (Thun et al., 1955)	0-2	Poor humic	112	44.09
	2-5	Less humic	141	55.51
	>5	Humic	1	0.39

3.1.4. Lime

The lime content of the soils ranged between 1.16-74.50% (Table 2). According to Evliya (1964), 37.01% of the soils were low, 16.14% were limy, 12.99% were high, 10.63% were very high and 23.23% were in the extreme class (Table 4). Olive develops very well in calcareous soils (Kacar and Katkat, 1999). It is known that olives tolerate a wide limit in terms of lime, and olive does not lose anything from their productivity (Colakoglu, 1985). However, it shows the best development in 9-19% so that it contains moderately lime (Hartmann and Lilleland, 1966); (Llamas, 1984); (Mengel and Kirkby, 1987). As a result of the study, 34.40% of olive groves were found to contain low lime. Olive is actually a drought tolerant plant that can grow in a wide soil reaction, tolerates lime. However, purchasing quality and abundant products requires special conditions to be met (Ozbek, 1981); (Llamas, 1984). For this reason, it is thought that it will be beneficial to make the appropriate amount of liming in the areas with low lime in the region. Approximately 60% of the area of the research contains high lime (Table 4). For this reason, it is necessary to choose fertilizers with low lime rates and to apply organic fertilizer applications in these areas with high lime content in chemical fertilization. In some studies carried out to determine the nutritional status of olives, it was determined that 32.84% of the soils are low in the Western Anatolia Region, 29.35% is limy, 19.90% is high and 17.91% is very high lime (Turan et al., 2013); 50% of the lime is rich in Izmir province (Aydogdu, 2011); the majority of the Kapidag peninsula is low calcareous level (Saglam et al., 2008). In the Derik region, CaCO₃ levels vary between 5.03-13.41% and are in the class of lime-rich soils (Doran et al., 2008) and 47.06% in the Urfa region are too lime and 32.35% are too lime (Soylemez et al., 2017) and olive groves do not contain lime in the Armutlu peninsula (Uysal et al., 2016).

3.1.5. Organic matter

Organic matter contents ranged between 0.86-5.74% (Table 2). According to Thun et al. (1955), soils of 44.09% were humus poor, 55.51% is less humus, and 0.39% is humic (Table 4). According to the results of the analysis, the organic matter coverage of olive groves is low and proportionally a great majority of soils fall into the less and less class. Olive loves soils with well-ventilated and sufficient moisture. Barnyard manure creates this environment and increases the effectiveness of commercial fertilizers. Because of this reason, it should be applied to the soil adequately and accurately. In addition, an ideal growing environment should be created by combining the soil with organic and inorganic fertilization (Ozbek, 1981); (Cakir and Cavusoglu, 1988). Special attention should be given to the release techniques, the common use of barn manure and green fertilization to improve the soil organic matter level. Organic matter content of soils in the Western Anatolia Region is 26.37% very low, 58.21% low, 12.44% sufficient and 2.98% high (Turan et al., 2013). It was determined that in Izmir province (Aydogdu, 2011) and Kapidag peninsula (Saglam et al., 2008), all of them are low, in the Gemlik region, 22.7% are few and very little, 47.7% are medium and 29.7% are high and very high (Uysal et al., 2011), 28.9% are low in Armutlu peninsula, 30.9% are medium and 40,2% is determined at a high and very high level (Uysal et al., 2016). While it varied between 1.29-1.98% in the Derik region (Doran et al., 2008), it was changed between 0.37-2.32% in the province of Sanliurfa (Soylemez et al., 2017) and both were reported to be insufficient.

Table 5. The status and distribution of soil in term of microelements

Nutrient	Limits (mg kg ⁻¹)	Evaluation	Number of sample (piece)	Distribution (%)
B	<0.5	Little	35	13.78
	0.5-2.00	Adequate	194	76.38
	2.00-5.00	Much	24	9.45
	>5.00	Too much	1	0.39
Fe	<2.5	Lack	3	1.18
	2.5-4.5	Lack visible	11	4.33
	>4.5	Well	240	94.49
Cu	<0.2	Insufficient	3	1.18
	>0.2	Sufficient	251	98.82
Zn	<0.2	Too little	3	1.18
	0.2-0.7	Little	84	33.07
	0.7-2.4	Sufficient	127	50.00
	>2.4	Much	40	15.75
Mn	<0.2	Too little	0	0.00
	0.2-0.7	Little	0	0.00
	0.7-5	Sufficient	21	8.27
	>5	Much	233	91.73

3.1.6. Extractable B

The extractable B contents of soils ranged between 0.20 to 5.24 mg kg⁻¹ (Table 3). When the extractable B content of soils were evaluated according to Wolf (1971) 13.78% of the soils were classified as low, 76.38% adequate, 9.45% much and 0.39% too much (Table 5). Total B coverage of the soils is between 20-200 mg kg⁻¹ and the available B fraction is between 0.4-5.0 mg kg⁻¹ (Gupta, 1979); (Deliboran and Savran, 2017). If the amount of extractable boron of the soils is less than 0.5 mg kg⁻¹, the amount of boron suitable for the plant is insufficient, and if it is between 0.5-5.0 mg kg⁻¹, the amount of boron suitable for the plant is sufficient (Sillanpaa, 1982); (Deliboran and Savran, 2017); (Deliboran et al., 2019a). In this context, it is considered that the area of the research is sufficient in terms of B content. In some studies conducted to determine the nutritional status of olives, boron content of soils is low in the Western Anatolia Region, 32.84% low, 63.18% sufficient and 3.98% high (Turan et al., 2013). In Izmir province, boron contents of soils ranged between 1.47-5.34 mg kg⁻¹ and 1.15-3.87 mg kg⁻¹ in term of variety and the soils are sufficient class (Aydogdu, 2011). In another study, the boron contents of some olive cultivation areas in Izmir province varied between 0.20 and 5.24 mg kg⁻¹ and it was insufficient in approximately 27% (Deliboran et al., 2019). The B content of olive groves was ranged between 0.37-0.53 mg kg⁻¹ in the Derik region and it was inadequate (Doran et al., 2008), while it was insufficient in 100% in Sanliurfa province (Soylemez et al., 2017).

3.1.7. Extractable Fe, Cu, Zn and Mn

The extractable Fe contents of soils varied from 1.62 to 92.81 mg kg⁻¹. According to the limit values, 1.18% of the soils were lack, 4.33% were lack visible, 94.49% were well class. The extractable copper contents ranged from 0.13 to 20.60 mg kg⁻¹, 1.18% of soils were insufficient, 98.82% were sufficient class. Extractable zinc contents ranged from 0.09 to 9.15 mg kg⁻¹, 1.18% of the soils were too little, 33.07% were little, 50.00% were sufficient and 15.75% were much. The extractable manganese contents ranged from 0.96 to 78.60 mg kg⁻¹, 8.27% of the soils were sufficient, 91.73% were much class (Table 3; 5). When the results are evaluated as a whole, it can be said

that the soil cultivated in the research area is sufficient in terms of manganese and insufficient in terms of iron, copper and zinc. In a study conducted in the Western Anatolian Region in order to determine the nutritional status of olives, approximately 35% of the soils in terms of Fe and Cu contents; 72% in terms of Zn and 11% in terms of Mn are determined in the low and critical class (Turan et al., 2013). In another study, the iron content of the soil in Izmir province varied between 1.43-3.02 mg kg⁻¹ / 1.15-4.13 mg kg⁻¹, respectively for Uslu and Domat olive varieties, and all of them were low and critical. It has been reported that the contents of the extractable Cu, Zn and Mn varied between 1.11-3.31 mg kg⁻¹ / 0.43-2.55 mg kg⁻¹; 0.86-2.66 mg kg⁻¹ / 0.14-2.76 mg kg⁻¹; 0.76-2.71 mg kg⁻¹ / 0.43-1.87 mg kg⁻¹ respectively, and all three elements were in sufficient class (Aydogdu, 2011). In another study conducted in Izmir province, it has been reported that the extractable Fe, Cu, Zn and Mn contents of olive groves were varied between 2.82-92.81 mg kg⁻¹; 0.41-20.60 mg kg⁻¹; 0.36 and 9.15 mg kg⁻¹ and 3.47-78.60 mg kg⁻¹, respectively. In term of iron, copper, zinc and manganese, 94%, 100%, 80% and 99% of soils were sufficient class. It has been reported that zinc feeding problems were experienced in the region (Deliboran et al., 2019b). The content of Fe, Zn, Mn and Cu of olive groves in the Derik region ranged between 6.18-11.3 mg kg⁻¹, 3.14-9.27 mg kg⁻¹; 5.32-8.08 mg kg⁻¹ and 1.63-3.48 mg kg⁻¹, respectively and all of them were identified sufficient class (Doran et al., 2008). In Sanliurfa province, the extractable Fe and Cu contents of the soils varied between 1.92-4.13 mg kg⁻¹ and 0.85-2.30 mg kg⁻¹, respectively and 100% of them were medium and sufficient, Mn and Zn contents ranged between 1.80-6.44 mg kg⁻¹ and 0.18-0.55 mg kg⁻¹, respectively, and it were determined that 100% of soils were too little and little class (Soylemez et al., 2017).

3.2. Plant analysis results

The lowest, highest and average element analysis results of leaf samples are given in Table 6 and microelement content and distribution of leaves are given in Table 7.

Table 6. The lowest, highest and average values of total B, Fe, Cu, Zn and Mn concentrations of leaf samples

Values	B	Fe	Cu	Zn	Mn
	(mg kg ⁻¹)				
Minumum	8.66	23.57	3.06	3.95	8.39
Maximum	29.33	487.68	281.81	39.14	105.13
Average	16.94	120.27	18.105	14.21	27.86

3.2.1. Total B content of olive leaves

Total B content of olive leaves varied between 8.66-29.33% (Table 6) and according to the limit values, 85.04% of the leaves samples were little, 14.96% were adequate class (Table 7). According to Reuters and Robinson (1997) B limit values of olive leaves varies between 20-150 mg kg⁻¹, and according to Jones et al. (1991), it varies between 20-75 mg kg⁻¹. Considering that of 13.78% of the research area soils has boron feeding problems, 86.22% of soils contain adequate, much and too much boron, and 85.04% of the leaves contain little B, it is understood that approximately 86% of the olive grown areas in Izmir and Mugla province has a serious boron nutritional problems (Table 7). Although there is sufficient boron in almost all soils, the lack of boron in 85.04% of the leaves indicates that plant does not benefit from the boron in the soil. In the surveys conducted to determine the nutritional status of our country's olive groves, it was determined that the most B, Zn, K, and N deficiencies were found according to the order of importance (Canozer, 1978); (Dikmelik, 1989); (Genc et al., 1991); (Aksalman et al., 1993); (Tekin et al., 1994). (Doran and Aydın, 1999); (Deliboran et al., 2019); According to Deliboran et al. (2019) in a study conducted in the olive groves of Izmir province, the total boron content of leaves varied between 8.66-24.23%; although 27.13% of soils contained a low level of boron, approximately 78% of leaves were little class, it was understood that there was a serious problem of boron nutritional in Izmir province. It is thought that boron fertilizer applications should be made especially in the regions with boron deficiency. Ozbek (1981) reported that it may be inconvenient to apply to fruit trees with boron deficiency due to the fact that this element is very close to the boundary where the deficiency boundary and the poison effect, so that the desired boron levels in fruits and leaves

can be achieved by spraying boron from the leaf. He reported that the boron deficiency in boron or boric acid solution could be eliminated by spraying the leaves at a concentration of 0.15-0.24% in many fruit species. Perica et al. (2001a) investigated the boron movement, mannitol and glucose concentrations in different organs of the Manzanillo olive cultivar in yield age and the effects of change of B application on soluble carbohydrates using labeled B. They reported that after application from leaves of various ages treated with 10B application, there was a significant 10B output and a significant 10B increase occurred in neighboring organs that did not apply in inflorescences and fruits. The results proved that B can be carried from leaves of different ages and that B, which is applied from the leaves in olives, is portable in phloem. Soluble carbohydrate analysis found that mannitol and glucose were the dominant sugars in all organs analyzed and that the concentration of mannitol in the leaves was sufficient to calculate the entire B transport.

3.2.2. Total Fe, Cu, Zn and Mn

The total Fe, Cu, Zn and Mn contents of olive leaves ranged between 23.57-487.68%; 3.06-281.81%; 3.95-39.14%; 8.39-105.13%, respectively (Table 6). Distribution of olive leaves in terms of Fe content were 1.18% little, 98.82% adequate class; in terms of Zn content, 66.54% little, 33.46% adequate and much; in terms of Mn contents, 20.08% little, 79.92% adequate and much; in terms of Cu contents 10.63% little, 89.37% adequate and much (Table 7). Considering that 5.51% of the soil samples were lack and lack visible class (Table 5) and 1.18% of the leaf samples were little class (Table 7), it is understood that there is a small feeding problem in terms of Fe. In term of Zn considering that 34.25% of the soils were too little and little class (Table 5) and 66.54% of the leaves were little class (Table 7), it is understood that serious Zn nutrition problems are observed. In terms of Cu, 1.18% of the soil were insufficient (Table 5) and 10.63% of the leaves were little class (Table 7), in terms of Mn, 100% of the soil were sufficient (Table 5) and 20% of the leaves were little, it is understood that there is small Cu and Mn nutritional problems in the research province. According to Deliboran et al. (2019), the total Fe, Cu, Zn and Mn contents of the leaves were ranged between 23.57-201.25%; 3.06-169.52%; 3.96-35.73%; 8.39-105.13%, respectively. The researchers said that there were a serious nutritional problems of Cu, Mn and Zn, 7%, 17% and 64%, respectively and there were not nutritional problems of Fe.

Table 7. Micro elements status and distribution of leaf samples

Nutrient	Limit (%)	Evaluation	Number of sample	Distribution (%)
B	<20	Little	216	85.04
	20-150	Adaquate	38	14.96
	150<	Much	0	0.00
Fe	<30	Little	3	1.18
	30-40	Adaquate	7	2.76
	40<	Much	244	96.06
Zn	<15	Little	169	66.54
	15-30	Adaquate	82	32.28
	30<	Much	3	1.18
Mn	<20	Little	51	20.08
	20-35	Adaquate	156	61.42
	35<	Much	47	18.50
Cu	<4	Little	27	10.63
	4-10	Adaquate	184	72.44
	10<	Much	43	16.93

4. Conclusions

In this study, the boron nutritional status and some properties of olive cultivated areas in Izmir and Mugla provinces were examined, and the effects of the obtained results on olive farming were evaluated.

According to the results of the research; the vast majority of the research area soils have sandy loamy and clayey loamy structure, the content of organic matter is low. Soils with mild alkaline, neutral and mid acid properties are included in the saltless class. Considering that the olive tree can be grown in a wide soil reaction and shows good development in slightly acidic and slightly alkaline soils, it is seen that the territory of the region is suitable for olive farming in this respect. Since the vast majority of the research area soils contain high lime, particular care should be taken in selecting fertilizers with low lime rates in chemical fertilization. Considering that olives love soils with good air and sufficient moisture, the manure that creates this environment and increases the efficiency of its commercial fertilizers should be applied to the soil adequately and correctly. Also, an ideal growing environment should be created by combining the soil with organic and inorganic fertilization. Special attention should be paid to release techniques, widespread use of barn manure and green manure to improve its level. When the research results are evaluated as a whole in terms of boron, zinc, iron, copper and manganese, it is understood that there are serious nutritional problems in terms of B and Zn. It was also determined that there were nutritional problems, although not very serious in terms of Fe, Cu and Mn. Although 86.22% of the soils contain sufficient boron, the lack of boron in 85% of the leaves indicates that the plant does not benefit from boron in the soil. In this context, in order to eliminate these nutritional problems in the research area, particular importance should be given to boron, zinc, copper, iron and manganese fertilization.

It is thought that the fruit boron deficiency should be applied precisely from the soil due to the fact that this element is very close to the boundary deficiency and the poison effect of this element. Also it is thought that the desired level of the leaves in fruits trees can be achieved more easily by spraying the boron from the leaf due to the fact that the boron applied from the leaf can easily be carried in the phloem. Considering the results of this study carried out in Izmir and Mugla, it is understood that effective fertilization program, method and time are extremely important. It is thought that quality and high-efficiency production in olive farming can be possible with balanced fertilization, organic fertilizer addition and other technical applications meticulously.

References

- Aksalman, A., Dikmelik, U., Puskulcu, G., Ozgen, N. (1993). Determination of the nutritional status of the olives of Aydin region. Final Report, Olive Research Station, Izmir, Turkey.
- Anonymous, (1951). Soil Survey Manuel. Agricultural Research Administration, Department of Agriculture Handbook, No:18, Gount Point Office Washington, USA, 340-377.
- Anonymous, (2011). <http://www.tuik.gov.tr> (accessed date: 29.03.2015)
- Anonymous, (2014). <http://www.internationaloliveoil.org>. (accessed date: 01.05.2015)
- Aydogdu, E. (2011). *Nutrient content of leaves in Domat and Uslu olive varieties and investigation of their seasonal changes*. (Master Thesis) Cukurova University. Institute of Science, Soil Science and Plant Nutrition Department, Adana, Turkey.
- Canozer, O. (1978). *Nutrient elements status and soil-plant relationship of major olive varieties in the Aegean region*. (Specialization Thesis) Olive Research Institute, Bornova, Izmir.
- Cakir, M., Cavusoglu, A. (1988). Modern Olive. T.O.K.B. Publication No: 1, Ankara, Turkey.
- Colakoglu, H. (1985). Fertilizer and Fertilization. Ege University, Agriculture Faculty Duplication, 17:1. Bornova, Izmir, Turkey.
- Deliboran, A., Savran, S. (2017). Boron, its importance in plant physiology and its use in fruit trees. *5th International Participation of Soil and Water Resources Congress*. 12-15 September, Kirklareli, Turkey.
- Deliboran, A., Savran, K., Dursun, O., Eralp, O., Pekcan, T., Turan, H.S., Aydogdu, E., Cilgin, I., Ata Olmez, H., Savran, S., Ozturk Gungor, F., Yildirim, A., Nacar, A.S. (2019). Determination of nutritional status of olives (*olea europaea* l.) grown in mugla province in terms of boron and other elements, leaf and soil relations. *IJAAES International Journal of Anatolia Agricultural Engineering* ISSN: 2667-7571, (Private No 1): 126-140.
- Deliboran, A., Savran, K., Dursun, O., Eralp, O., Pekcan, T., Turan, H.S., Aydogdu, E., Cilgin, I., Ata Olmez, H., Savran, S., Nacar, A.S. (2019a.). Determination of nutritional status in terms of boron and the other elements of olives (*Olea europaea* L.) grown in Izmir province. *International Sempodium on Boron*. 17-19 April, Nevsehir, Turkey.
- Deliboran, A., Savran, K., Dursun, O., Eralp, O., Pekcan, T., Turan, H.S., Aydogdu, E., Cilgin, I., Ata Olmez, H., Savran, S., Ozturk Gungor, F., Yildirim, A., Nacar, A.S. (2019b). Determination of Nutritional Status of Olives (*Olea europaea* L.) Grown in Mugla Province in Terms of Boron and Other Elements, Leaf and Soil Relations. *6. International Participant Soil and Water Congress*. 12-14 November, Menemen, Izmir, Turkey.
- Dikmelik, U. (1984). A research on the determination of grain and pruning residues and nitrogen, phosphorus, potassium amounts removed from the soil in nipple olive trees of different ages. Olive Research Institute, Publication No: 31, Bornova, Izmir, Turkey.
- Doran, I., Koca, Y.K., Pekkolay, B., Mungan, M. (2008). Determination of the nutritional status of Derik region olive groves. *Journal of Akdeniz University Faculty of Agriculture* 21(1): 131-138.
- Doran, I., Aydın, R. (1999). Determination of the nutritional status of the Icel region olive groves. *Anadolu Journal of Aegean Agricultural Research Institute* 9 (1): 105-130.
- Evliya, H. (1964). Nutrition of Cultivated Plants. Publications of Ankara University, Agriculture Faculty, No: 36, Ankara, Turkey.
- Genc, C., Moltay, I., Soyergin, S., Fidan, A.E., Sutcu, A. (1991). Nutritional status of table olives in Marmara region. *Bahce, Yalova* 20: 1-2.
- Gestring, W.D. Soltanpour, P.N. (1981). Evaluation of wet and dry digestion methods for boron determination in plant samples by ICP-AES. *Communication in Soil Science and Plant Analysis* 12: 743-753.
- Gupta, U.C. (1967). A simplified method for determining hot water-soluble boron in soils. *Soil Science* 103: 424-428.
- Gupta, U.C. 1979. Boron nutrition of crops, *Adv. Agronomy* 31: 273-307.
- Hartmann, H.T., Lilleland, O. (1966). Olive Nutrition Temperate to Tropical Fruit Nutrition (Ed: N. F. Childers) Hort. Pub. Rutgers, Chapter X. The State University, New Jersey.
- Jones, J.R. Wolf, B., Mills, H.A. (1991). Plant analysis handbook: A practical sampling, preparation, analysis and interpretation Guide. Micro-Macro Publishing, Athens, GA. Micro-Macro Publishing.
- Kacar, B. (1982). Fertilizers and Fertilization Technique. T.C. Ziraat Bank Cultural Publications, Ankara, Turkey.
- Kacar, B., Katkat, A.V. (1999). Fertilizers and Fertilization Technique. Uludag University Strengthening Foundation Release, No. 144, VIPAs, Publication No: 20, Bursa, Turkey.
- Kasirga, E. (2009). Investigation of the effects of salinity on Gemlik olives (*Olea europaea* L.) cultivar. Adnan Menderes University, Institute of Science, ZTO-YL-2009-0003.
- Lindsay, W. L. Norwell, W. A. (1978). Development of a DTPA soil test for zinc, iron, manganese and copper. *Soil Science Society of America Journal* 42: 421-428.
- Llamas, J. F. (1984). Basis of fertilization in olive cultivation and the olive trees vegetative cycle and nutritional needs. International Course on Fertilization and Intensification of Olive Cultivation, UNDP-FAO, Cordoba-Spain.
- Mengel, K., Kirkby, A. (1987). Principles of Plant Nutrition. I.P.I. CH. 3048, Worblaufen-Bern.

Olive Oil Sector Report (2013). ISBN: 978-605-9175-57-9.

Olsen, S. (1972). Micronutrient interactions, micronutrients in agriculture. *Soil Science Society of America Ine Madison, Wisconsin USA*, 243-264.

Ozbek, N. (1981). Fertilization of Fruit Trees. T.O.K.B. 280 p, Ankara, Turkey.

Perica, S, Bellaloui, N., Greve, C., Hu, H., Brown, P.H. (2001a). Boron transport and soluble carbohydrate concentrations in olive.. *Journal of American Society Science* 126(3): 291-296.

Reuter, D.J., Robinson, J.B. (1997). Plant Analysis and Interpretation Manual. CSIRO Publishing. ISBN: 643059385, Collingwood, VIC, Australia.

Saglam, M.T., Bellitürk, K., Hazinedar, N., Danisman, F. (2008). Nutritional status of Kapıdağ peninsula olive groves. *Selcuk University, Journal of the Faculty of Agriculture* ISSN: 1300-5774, 22(44): 118-123.

Sillanpaa, M. (1982). Micronutrients and the Nutrient Status of Soils. A Global Study. FAO Soils Bulletin No:48, Rome.

Soylemez, S., Oktem, G., Kara, H., Almaca, N.D., Ak, B.E., Sakar, E. (2017). Determination of the nutritional status of the olive groves of Sanliurfa region. *Harran Journal of Agricultural and Environmental Sciences* 21(1): 1-5.

Tekin, H., Caglar, G., Kuru, C., Akkok, F. (1990). Determination of the nutritional content of pistachios and determination of the most appropriate leaf sample time. *1. Turkey Pistachio Symposium Proceedings*. 11-12 September, P. 120-138, Turkey.

Thun, R., Hermann, R., Knickman, E. (1955). Die Untersuchung Von Boden Neuman Verlag, Radelbeul und, p: 48-48, Berlin.

Turan, H.S., Aydogdu, E., Pekcan, T., Colakoglu, H. (2013). Relationships of olive groves in West Anatolia region of Turkey. Copyright © Taylor & Francis Group, LLC ISSN: 0010-3624 print / 1532-2416 online DOI: 10.1080/00103624.2012.734133, *Communications in Soil Science and Plant Analysis* 44: 80–88.

Turan, H.S., Aydogdu, E., Pekcan, T., Colakoglu, H. (2013). Soil and plant relationships olive groves in West Anatolia region of Turkey. *Soil, plant and Food Interactions* 473-481.

Tuzuner, A. (1990). Soil and Water Analysis Laboratory Handbook. Ankara.

Uysal, E., Albayrak, B., Soyergin, S. (2011). Determination of nutritional status of olives grown in Gemlik region by soil analysis. 2nd National Soil and Water Resources Congress, 22-25 November Ankara, p: 887-895.

Uysal, E., Albayrak, B., Kayali, F., Karakoc, A. (2016). Determination of the relationship between yield and some soil properties in olive groves grown in Armutlu region. *Nevsehir Journal of Science and Technology TARGID*, Special Issue 19-31 DOI: 10.17100 / nevbiltek.210955 URL: <http://dx.doi.org/10.17100/nevbiltek.210955>.

Wolf, B. (1971). The Determination of boron in soil extracts, plant materials, composts manures, water and nutrient solutions. *Communications in. Soil Science and Plant Analysis* 2: 363-374.