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ARAŞTIRMA MAKALESİ **RESEARCH ARTICLE**

Carbon and Nitrogen Stocks of Olive Orchard Soils in Izmir Province

İzmir Yöresi Zeytin Bahçe Topraklarının Karbon ve Azot Stokları

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Abstract

Soil organic carbon (SOC) and total nitrogen (TN) have a very important role in sustainable soil quality, crop production, and environmental impacts, and determining of carbon nitrogen ratio (C: N ratio) is very important for creating data banks in terms of ecosystem functions. Plants influence the interaction of SOC and TN, as well as ecosystem yield and the continental carbon cycle. Climate, atmosphere, and land-use change are all included in numerical models of the carbon (C) and nitrogen (N) cycles. This study was conducted to determine the SOC and TN stocks, the C: N ratio and their relationships with the soil properties of olive orchards in Aliaga, Bayindir, Bergama, Dikili, Foca, Karaburun, Kemalpasa, Menderes, Menemen, Odemis, Seferihisar, Selcuk, Tire, Torbali and Urla provinces of Izmir in Turkey. For this purpose, 129 soil samples were taken from 0-30 cm depth. The texture, pH, EC, lime, OM, SOC and TN content and stocks, Bulk density (Db) was determined. Db and C: N ratio varied between 0.84-1.31 g cm^{-3}, 5.17-80.50, and SOC density and stocks changed between 4.00-53.00 mg cm^{-3}, 1.25-1.59 kg m^{-2}, N density and stocks between 0.09-2.66 mg cm^{-3}, 0.03-0.80 kg m^{-2}, respectively. The highest BD was obtained from Tire, the highest SOC stocks from Karaburun, the highest TN from Seferihisar and Karaburun. The very small bulk density which is negatively associated with OM and clay is an important feature. The SOC contents were higher in relatively heavy rainfall regions. SOC and soil texture have a strong relationship. As a result, texture, precipitation, temperature, soil depths, and regeneration of soil affect the SOC and TN stocks. The results may be effective in terms of sustainable soil quality and ecosystem functions for olive cultivation.

Keywords: Total nitrogen stocks, Soil organic carbon stocks, Bulk density, Olive orchards

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Öz

Toprak organik karbonu (SOC) ve toplam azotu (TN) sürdürülebilir toprak kalitesi, bitkisel üretim ve çevresel etkilerde çok önemli bir role sahiptir, Karbon: Azot (C: N) oranının belirlenmesi ise ekosistem fonksiyonları açısından veri bankalarının oluşturulması için oldukça önemlidir. Bitkiler, ekosistem verimi ve kıtasal karbon döngüsünün yanı sıra SOC ve TN etkileşimini de etkiler. İklim, atmosfer ve arazi kullanımındaki değişikliklerin tümü, karbon (C) ve nitrojen (N) döngülerinin sayısal modellerine dahil edilir. Bu çalışma, Türkiye de İzmir ili Aliağa, Bayındır, Bergama, Dikili, Foça, Karaburun, Kemalpaşa, Menderes, Menemen, Ödemiş, Seferihisar, Selçuk, Tire ve Torbalı ilçelerindeki zeytin bahçelerinin SOC ve TN stokları, C: N oranı ve bunların toprak özellikleri ile ilişkilerini belirlemek amacıyla yürütülmüştür. Bu amaçla 0-30 cm derinlikten 129 adet toprak örneği alınmıştır. Toprak tekstürü, toprak reaksiyonu (pH), elektriksel iletkenlik (EC), kireç, organik madde (OM), SOC ve TN içeriği ve stoklar, hacim ağırlığı (Db) değerleri belirlenmiştir. Sırasıyla, Db ve C: N oranı 0.84-1.31 g cm^{-3} ve 5.17-80.50 arasında, SOC yoğunluğu ve stokları 4.00-53.00 mg cm^{-3}, 1.25-1.59 kg m^{-2} arasında, N yoğunluğu ve stokları ise 0,09-2,66 mg cm^{-3} ve 0.03-0.80 kg m^{-2} arasında değişmiştir. En yüksek Db Tire'den, en yüksek SOC stokları Karaburun'dan, en yüksek TN ise Seferihisar ve Karaburun'dan elde edilmiştir. OM ve kil ile negatif ilişkili olan çok küçük kütle yoğunluğu önemli bir özelliktir. SOC içerikleri, nispeten yoğun yağış alan bölgelerde daha yüksekti. SOC ve toprak dokusu arasında güçlü bir ilişki vardır. Sonuç olarak, toprak tekstürü, yağış, sıcaklık, toprak derinlikleri ve toprağın yenilenmesi SOC ve TN stoklarını etkiler. Sonuçlar, zeytin yetiştiriciliği için sürdürülebilir toprak kalitesi ve ekosistem fonksiyonları açısından etkili olabilir.

Anahtar Kelimeler: Toplam azot stokları, Toprak organik karbon stokları, Hacim ağırlığı, Zeytin bahçeleri

1. Introduction

Carbon and nitrogen are very important due to their oxidation into the atmosphere in the global warming pursuance. Especially, the biogeochemical cycles of carbon and nitrogen are remarkable and the importance of this has increased in terrestrial ecosystems around the world. The largest factor of terrestrial carbon is soil organic carbon (SOC). The carbon amount that consists of SOC is bigger than the carbon current in live vegetation (Post and Kwon, 2000). Furthermore, the diversification of SOC pools has an additive effect on the carbon dioxide (CO_2) concentrations in the atmosphere (Smith, 2008). For these reasons, appreciation of SOC latent and improving efficient processes to reduce the atmospheric CO_2 concentration are critically significant (Fu et al., 2010).

The land-use alteration, growth, and other factors affect SOC stocks in different ways in distinct ecosystem and districts (Yimer et al., 2007). In the carbon and nitrogen cycle, soils play a critical act. According to Schlesinger (1997), soil includes approximately 75% SOC and 95% total nitrogen (TN). SOC and TN have a very important act in sustainable soil quality, crop production, and ecological impacts (Bauer and Black, 1994; Doran and Parkin, 1994). The TN content of soils has a significant impact on the fertility of the earth's soil. SOC sequestration is winning global care due to the expanding requirement to balance the quickly growing atmospheric level of CO_2. The fortification of CO_2 is connected with an increase in universal heating possible and alters in the quantity and effectuality of rainfall (Lal and Follet, 2009). The increase of nitrous oxide (N_2O) levels in the atmosphere is directly related to widespread human intervention in the nitrogen cycle, which is mostly influenced by agricultural activities (Prather et al., 1995). As tropical habitats are converted to agriculture, grazing, or silviculture, there is an increasing back demand for tropical soil N_2O emission to become extra crucial (Duxbury, 1994). For this reason, comprehension of soil carbon and N storage back demand and growing efficient procedures to reduce the CO_2 and N_2O levels of the atmosphere are crucial (Fu et al., 2010).

Plants influence the interaction of SOC and TN, as well as ecosystem yield and the continental carbon cycle. Climate, atmosphere, and land-use change are all included in numerical models of the carbon (C) and nitrogen (N) cycles (Pepper et al., 2005). The C: N ratio of soil provides information about the soil's degree of degradation and humus structure (Brady and Weil, 2008). While the C: N ratio is high, the decomposition of organic matter (OM) is slow, and while the C: N ratio is small, the decomposition takes place quickly. In short, the C: N ratios of soils are important in terms of the mineralization of OM (Sakin and Sakin, 2014). If the C: N ratio of the organic substance is more than 30, nitrogen immobilization occurs at the beginning of decomposition. If the C: N ratio of organic material has greater than 30, nitrogen immobilization occurs at the start of decomposition. If the C: N ratio is between 20-30, mineralization and immobilization are in balance. If this ratio is lower than 20, mineral nitrogen is released at the start of decomposition (Tisdale and Nelson, 1985).

In the soil, irrigation and fertilization parameters affect the C and N amounts and percentage ratios. According to studies, these two elements raised the amounts and proportion of C and N, and the C:N ratios (6.5:1-25.0:1) were substantially different (Kelliher et al., 2012; Schipper et al., 2012). Also, it is known that it is very difficult to realize that the bonding and storage times of C and N are long in a short time (Condron et al., 2012). The C: N ratio in soils ranges from 8 to 17 (Alistair Pitty, 1979), and it is a critical pointer to soil quality (Zhang et al., 2011), and it also affects pH, nutrient accumulation, and humic substance content in the soil (Yano et al., 2000). According to Berg and McClaugherty (2003) the density of humus levels and the C: N ratio have a significant correlation. Tillage degrades OM, and because of this, the C: N ratio is narrower in cultivated soils (Seeber and Seeber, 2005). Because of this, forest soils have a higher C: N ratio than agricultural soils (John et al., 2005; Puget and Lal, 2005). Also, OM regulates soil aggregation, thus increasing soil porosity, increasing porosity then increasing micropore, and resultantly decreases in soil bulk density (Erhart and Hartl, 2010; Aktas and Yuksel, 2020).

The soil C: N ratio is a soil fertility marker, due to the strong relationship between soil OC and N. Various factors change the soil C: N ratio, including climate (Miller et al., 2004), characteristics of soil (Ouedraogo et al., 2006), vegetation type (Diekow et al., 2005; Puget and Lal, 2005) or agricultural methodologies (Zhang et al., 2009). Mechanical, chemical, and biological reactions could not decompose soil OM because of the particle size distribution (Krull et al., 2003). The concentration of clay affects OC accumulation, and OC increased with increasing clay content (Burke et al., 1989). Compared to loamy soils, sandy soils have low OC and N content, and a higher C: N ratio. Similar results were taken for the central United States (Franzmeier et al., 1985); (Sims and Nielsen, 1986; Burke et al., 1989), as well as in other parts of the country (Grigal and Ohmann, 1992); (Conant et al., 1998; Homann et al., 2004) and some countries of the World (Paruelo, 1998; Hontoria et al., 1999). These findings revealed a variety of trends. SOC which was expected to increase with a decrease in temperature, decreased in southern Oregon (Homann et al., 1995), and Finland forests (Liski and Westman, 1997). Climatic conditions, seasonal weather diversity, altitude differences, and many factors may cause se variety of trends (Homann et al., 2007).

It is considered that determining of C: N ratio is very important for creating data banks in terms of ecosystem functions. In the literature review, it was determined that olive orchard soils were not examined in terms of C and N stocks, C: N ratio, and their relations with soil properties. Also, Izmir province and its districts, which have an important share in Turkey's olive cultivation, are considered to be important in this regard. The target of this study was to determine the amount of SOC and TN in olive orchard soils, as well as their stocks, C: N ratio, and relationships with other soil properties of Aliaga, Bayindir, Bergama, Dikili, Foca, Karaburun, Kemalpasa, Menderes, Menemen, Odemis, Seferihisar, Selcuk, Tire, Torbali and Urla provinces in Izmir.

2. Material and Method

2.1. Research area

The research was conducted in olive orchard fields of Izmir province in Turkey's Aegean Region (*Figure 1*). The effect of the Mediterranean climate is observed in that the summers are dry and hot, while the winters are mild and rainy. July and August are the hottest, while January and February are the coldest. The air temperature, precipitation, and sunshine duration for the mean yearly are 17.5 ^{0}C, 713.8 mm, and 8.1 hours, respectively, even though the number of days below zero does not reach ten (MGM, 2022).

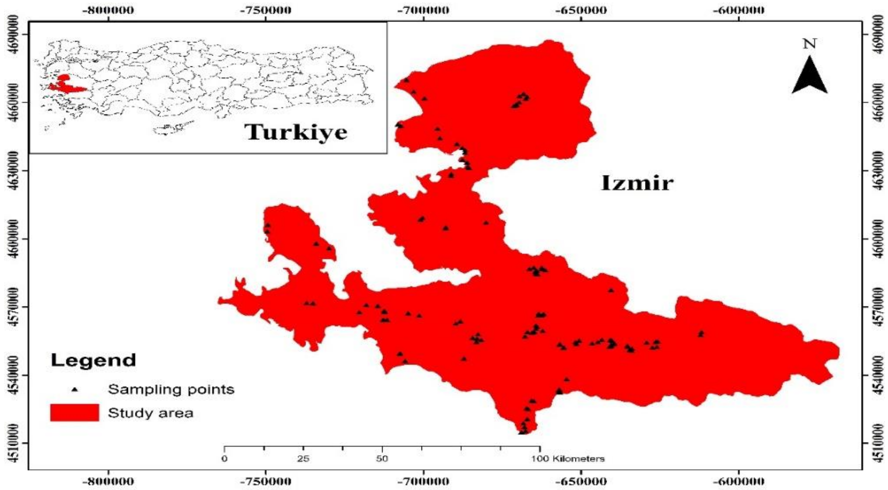

Figure 1. Izmir province and research region

2.2. Sampling method and soil analysis

In this study, samples of soil were taken consecutively from 0-30 cm depth with GPS coordinates in November-December 2015. These samples were analyzed after they were dried by air and sieved from 2 mm sieves. The texture was determined by the hydrometer method, and soil reaction (pH) by a pH meter from a soil + pure water mixture (1:2.5 ratio) (Tuzuner, 1990). While electrical conductivity (EC) was evaluated using an electrical permeability device from a 1:5 soil+distelled water mixture, lime ($CaCO_3$, %) as volumetric by Scheibler calcimetry, OM (%) by the Walkey-Black method (Tuzuner, 1990). The total C and N content was calculated by dumas method dry consumption with a LECO CNS-2000 analyzer (McGeehan and Naylor, 1988). Also, bulk density (Db) was made by Black (1965).

The soil C and N stocks were determined according to the following Equation (1):

$$E = d \times h \times (TOC\ or\ TN) \div 10 \quad \text{(Eq.1)}$$

E: The TOC or TN stock (mg ha^{-1}),
d: The soil bulk density (mg m^{-3}),
h: The sampled layer (cm),

TOC and TN are the total soil levels of organic C and N (g kg^{-1}), respectively, and 10 is the unit converter. OC density and N density was calculated according to the following Equation (2) and Equation (3):

$$OC\ dencity = \text{OC content } (\%) \times bulk\ density\ (g\ /\ cm) \times 10 \quad \text{(Eq.2)}$$

$$N\ density = N\ content\ (\%) \times bulk\ density\ (g\ /\ cm) \times 10 \quad \text{(Eq.3)}$$

Official classification set of soil mapping direction of the Geological State Offices of the Federal States of Germany (*Table 1*) were used for determined BD and OC contents (Arbeitsgruppe Boden, 2005).

Table 1. Official classification systems of soil mapping instruction of the Geological State Offices of the Federal States of Germany (in 30 cm depth of OC and N of soils of the allotment gardens of the northwestern Ruhr area) (Arbeitsgruppe Boden, 2005)

	Bulk density[a] g cm^{-3}	**OC content[a] %**	**OC density[b] mg cm^{-3}**	**OC stock kg m^{-2}**	**N content[c] %**	**N density[d] mg cm^{-3}**	**N stock kg m^{-2}**
Very low	<1.2	0.6	<9	<2	<0.04	<0.6	<0.2
Low	1.2-1.4	0.6-1.2	9-17	2-4	0.04-0.07	0.6-1.0	0.2-0.3
Modarate	1.4-1.6	1.2-2.4	17-32	4-8	0.07-0.13	1,0-1.7	0.3-0.5
High	1.6-1.8	2.4-4.8	32-56	8-16	0.13-0.24	1.7-2.8	0.5-0.8
Very high	1.8	4.8-8.7	56-80	16-24	0.24-0.42	2.8-3.9	0.8-1.2
Extreme high	-	>8.7	>80	>24	>0.42	>3.9	>1.2

[a] Arbeitsgruppe Boden (2005)
[b] Calculated from the regression equation: Bulk density = −0.065 × OC + 1.49; R2 = 0.49; n = 83;
[c] Calculated from the regression equation: N = 0.047 × OC + 0.0114; R2 = 0.81; n = 83
[d] Calculated from the regression equation: Bulk density = −1.33 × N + 1.49; R2 = 0.57; n = 83

3. Results and Discussion

3.1. Soil Properties of the Olive Orchard

Olive orchard soil properties of Izmir province were presented in *Table 2*. The sand, clay, and silt content of soils ranged from 22.95% to 83.68%; from 0 to 48.32%, and from 2.72% to 65.78%, respectively in General. While the soil reaction and lime ranged from 5.36 to 8.12, and from 1.16% to 73.22%; OM and EC ranged from 9.7 g kg^{-1} to 37.8 g kg^{-1}, and from 0.08 dS m^{-1} to 0.90 dS m^{-1} (*Table 2*). In General, according to Anonymous (1951), the majority of olive orchard soils (51.16%) were sandy loamy (SL), 17.05% of soils were clayed loam (CL), and 15.50% of soils were sandy clayed loam (SCL), 8.53% of soils clayey (C), 3.88% of loamy (L) and 3.10% of sandy (S) textured. Also, the vast majority of soils were slightly alkaline, neutral, and moderately acidic. All soils are characterized by low OM levels or in the low and poor humus class. This can be detailed with the soil textures. The SOM generation and mineral aggregation decline in the surface range of sandy soils and this decrease can be explained by the deeper level of highly transformed OM (Gonzalez Parra and Candas, 2004). For example in soils in the south of Europe, it is emphasized that low OM levels may be partially related to the semiarid Mediterranean condition (Gallardo et al., 2000). Also, studies have shown that most of the lands belonging to the olive orchards of the region are SL, CL, SCL, and a few soils is C texture, slightly alkaline and moderately acidic, salt-free, and poor in humus (Aydogdu, 2011; Turan et al., 2013; Deliboran et al., 2020).

Table 2. Descriptive statistics parameters of olive orchards soils in Izmir province

Province	**N**		**Texture (%)**			**pH**	**EC (dS m^{-1})**	**Lime (%)**	**OM (g kg^{-1})**
			Sand	**Clay**	**Silt**				
Aliaga	9	Mean	47.14	31.74	21.12	6.95	0.53	16.85	20.9
Bayindir	23	Mean	66.35	13.58	20.07	6.19	0.22	3.033	18.7
Bergama	12	Mean	42.02	38.87	19.11	7.73	0.61	17.42	18.4
Dikili	8	Mean	55.94	26.11	17.95	7.19	0.50	12.69	19.2
Foca	2	Mean	44.68	35.60	19.72	7.71	0.71	10.67	16.7
Karaburun	4	Mean	53.74	22.04	24.22	7.11	0.41	10.85	28.2
Kemalpasa	10	Mean	42.18	32.30	25.52	7.48	0.53	19.74	24.6
Menderes	9	Mean	45.43	27.88	26.69	7.54	0.41	26.73	25.0
Menemen	3	Mean	65.01	15.60	19.39	7.48	0.42	2.78	17.4
Odemis	8	Mean	71.74	14.29	13.97	6.41	0.19	1.59	13.9
Seferihisar	7	Mean	61.58	19.03	19.39	6.71	0.26	5.76	22.2
Selcuk	10	Mean	62.13	17.29	20.58	7.21	0.20	3.30	19.5
Tire	5	Mean	69.84	9.44	20.72	7.63	0.15	17.68	15.9
Torbalı	12	Mean	55.53	10.23	34.24	7.44	0.35	11.86	20.8
Urla	7	Mean	43.67	31.87	24.46	7.30	0.40	28.68	19.6
		Minimum	22.95	8.32	2.72	5.36	0.08	1.16	9.7
		Maximum	83.65	48.32	65.76	8.12	0.90	73.22	37.8
		Mean	55.66	22.15	22.09	7.10	0.368	12.14	20.09
General	129	Standart Devision	14.04452	12.3159	9.02838	0.68	0.20319	15.6274	5.72040
(Izmir)		Coefficient variation	0.26	0.56	0.41	0.10	0.55	1.28	0.28
		Variance	208.663	151.822	81.512	0.463	0.041	244.22	32.723
		Skewness	-0.318	0.275	1.345	-0.809	0.483	1.900	0.718
		Kurtosis	-0.933	-0.898	4.383	-0.498	-0.716	3.320	0.329

3.2. Bulk Density of the Olive Orchard Soils

In General, Db values ranged from 0.84 to 1.31 g cm^{-3}. The mean highest Db was obtained from Tire province. Tire was followed by Bayindir = Bergama = Menemen = Odemis = Torbali = Urla > Kemalpasa > Dikili = Selcuk > Menderes > Foca > Seferihisar > Aliaga > Karaburun (*Table 3*). The very low bulk density seen in loamy sandy and sandy loam soils is one of the most important features of garden soils (Burghardt and Schneider, 2018). In our study, these results were obtained from olive orchard soils, and Db has a negative correlation with OM (r=-0.189) and clay (r=-0.148) (P <0.05) (*Table 4*). Also, the majority of olive orchard soils (51.16%) were SL, 17.05% of

Tablo 3. Describe statistics parameters of Izmir province soils

Province	**N**		***Bulk density (Db, g cm^{-3})***	***Soil organic carbon (SOC, g kg^{-1})***	***SOC density (mg cm^{-3})***	***SOC stocks (kg m^{-2})***	***Total nitrogen (N, g kg^{-1})***	***N density (mg cm^{-3})***	***N stocks (kg m^{-2})***	***C: N ratio***
Aliaga	9	Mean	1.01	18.8	20.30	6.09	1.0	1.05	0.31	20.91
Bayindir	23	Mean	1.11	12.9	15.39	4.62	0.8	0.95	0.28	16.09
Bergama	12	Mean	1.11	18.5	20.78	6.23	0.8	0.90	0.27	22.53
Dikili	8	Mean	1.08	18.5	20.28	6.08	1.2	1.28	0.38	15.54
Foca	2	Mean	1.06	18.4	19.79	5.94	1.0	1.08	0.32	20.69
Karaburun	4	Mean	0.98	24.7	26.47	7.94	1.6	1.60	0.48	16.05
Kemalpasa	10	Mean	1.09	19.0	20.19	6.06	1.0	1.10	0.33	24.71
Menderes	9	Mean	1.07	23.4	25.44	7.63	1.3	1.41	0.42	19.77
Menemen	3	Mean	1.11	11.3	12.80	3.84	1.2	1.32	0.40	9.60
Odemis	8	Mean	1.11	8.0	8.92	2.68	0.8	0.83	0.25	10.80
Seferihisar	7	Mean	1.03	18.3	20.96	6.29	1.6	1.73	0.52	12.68
Selcuk	10	Mean	1.08	14.4	15.58	4.67	1.1	1.19	0.36	13.12
Tire	5	Mean	1.14	19.7	21.96	6.59	0.9	1.09	0.33	27.13
Torbalı	12	Mean	1.11	17.6	19.45	5.84	1.1	1.22	0.37	16.50
Urla	7	Mean	1.11	19.3	23.99	7.20	1.1	1.24	0.37	15.81
		Min.	0.84	4.3	4.00	1.25	0.1	0.09	0.03	5.17
		Max.	1.31	43.1	53.00	15.93	2.4	2.66	0.80	80.50
		Mean	1.09	17.0	18.49	5.55	1.1	1.13	0.34	17.52
General (Izmir)	129	Standart Devision	0.09176	9.16671	10.16513	3.05902	0.47253	0.50875	0.15259	9.42483
		Coefficient variation	0.08	0.59	0.55	0.55	0.45	0.51	0.45	0.54
		Variance	0.008	84.029	103.330	9.358	0.223	0.259	0.023	89.426
		Skewness	0.039	0.953	1.127	1.134	0.492	0.541	0.544	3.181
		Kurtosis	0.078	0.285	1.100	1.120	-0.341	-0.069	-0.072	16.006

soils were CL, and 15.50% of soils were SCL textured. Increased SOC with the addition of compost reduces the Db of garden soils (Maynard, 2000), and there is a negative correlation between Db and OC content (Burghardt and Schneider, 2018). According to Kashi et al. (2016); the Db of walnut garden soils was 1.74 mg m^{-3} at 25 cm depth. Db of soils with different land use investigated, the lowest Db was obtained from irrigated farmland (1.01 g cm^{-3}), and the highest Db was determined from the orchard (1.52 g cm^{-3}) ($P < 0.05$) (Ozturkmen et al., 2021). It is known that intensive use of animal manure increases the bulk weight of soils (Adeyemo et al., 2019). According to Brye et al. (2005), increasing doses of farm manure gradually reduces the Db and soil prevents jamming. Like results were found in other studies (Ozturkmen et al., 2020; Ozturkmen and Ramazanoglu, 2020).

3.3. Soil Organic Carbon (SOC), Total Nitrogen (TN), and C: N Ratio

In General, SOC, TN content and C: N ratio varied between 4.3-43.1 g kg^{-1}; 0.1-2.4 g kg^{-1} and 5.17-80.50, respectively. While the mean SOC values of all province were ordered as follow: Karaburun > Menderes > Tire > Urla > Kemalpasa > Aliaga > Bergama = Dikili > Foca > Seferihisar > Torbali > Selcuk > Bayindir > Menemen > Odemis, the mean TN content of all province as follow: Karaburun = Seferihisar > Menderes > Dikili = Menemen > Selcuk = Torbali = Urla > Aliaga = Foca = Kemalpasa > Tire > Odemis = Bergama = Bayindir (*Table 3*). According to the classification of Arbeitsgruppe Boden (2005) (*Table 1*), while Karaburun (24.7g kg^{-1}=2.47%) was high, and Odemis (8.0 g kg^{-1}=0.8%) was low; the other province moderate in terms of SOC content; Karaburun (1.6 g kg^{-1}=0.16%), and Seferihisar (1.6 g kg^{-1}=0.16%) were high, the other provinces were moderate in terms of TN (*Table 3*). The mean C: N values of all province were ordered as follow: Tire > Dikili > Kemalpasa > Bergama > Aliaga > Foca > Menderes > Torbali > Bayindir > Karaburun > Urla > Selcuk > Seferihisar > Odemis > Menemen (*Table 3*). Clay percent showed a positive relation with SOC content (r=0.146), ratio of C: N (r=0.187) and with OM (r=0.209) ($P<0.05$). Content of SOC may increase by increasing soil clay content (Nichols, 1984; Burke, 1989), but this should not be generalized, other parameters such as the aluminum level of the soil or particular surface area may also change the SOC level (Percival et al., 2000; Krull et al., 2003). Our study, especially when compared to soil organic matter (OM) models such as Century (Parton et al., 1987) and RothC (Jenkinson, 1990), which suggest that OM solubility decreases as clay concentration increases, it is thought that the correlation of clay concentration and SOC content is important. According to Hernanz et al. (2009), semiarid regions soils of the Mediterranean have a low SOC content because of strong OM mineralization and the lack of harvest wastes following drought periods on rainfed crops. Some researchers reported that soils by tree cover exhibit an increase at C and N which is similar to our findings (Albretch and Kandji, 2003; Parras-Alcantara et al., 2013).

As a result of our study, the great majority of olive orchard soils were SL, CL, and SCL texture, and as a result of these properties, the SOC of soils ranged from 8 g kg^{-1} (Odemis) to 24.7 g kg^{-1} (Karaburun). Also, SOC content showed a positive significant correlation between TN (r=0.684) and the ratio of C: N (r=0.331) while TN showed a negative relation to C: N ratio (r=-0.297) ($p<0.01$). OM level showed a positive significant relationship by SOC (r=0.223) and TN content (r=0.284) ($p<0.01$) (*Table 4*). Parras-Alcantara et al. (2013) claimed that SOC content is 10.1 g kg^{-1} and TN values are 1.07 g kg^{-1} in olive orchard soils at 27 cm depth, and also TN content and C: N ratio decrease at 27cm< depth, and that this is related to an increase in soil clay content by depth (between 27-176 cm). Greater clay content is often connected with high decomposed OM and a lower C: N ratio (Puget and Lal, 2005; Yamashita et al., 2006; Kashi et al., 2016). At 25 cm depth of walnut gardens soils, SOC, TN, and C: N was 3 g kg^{-1}, 0.33 g kg^{-1}, and 31.2, respectively (Kashi et al., 2016). C: N ratios range from 8:1 to 15:1 in the Mississippi River Delta region of eastern Arkansas (Brady and Weil, 2008) and between 4.32:1 and 6.04:1 in Harran plain soils (Sakin et al., 2011b). It is known that C: N ratio was induced by low rainwater, full resolution, extraction rates, or extreme cultivation techniques. The C: N increases by precipitation, while it reduces by increased temperatures (Miller et al., 2004). According to Callesen (2007), there is a positive correlation between C: N ratios, rainwater, and temperature. Also, it is argued that although the cultivation methods and farming activities utilized 10 years ago had not affect C: N ratios (Sainju et al., 2008; Fu et al., 2010), techniques of modern farming and agriculture do (Puget and Lal, 2005; Yimer et al., 2007).

Table 4. The relationship between measured soil parameters, BD, SOC, TN stock and C: N

	SOC	**TN**	**C/N**	**pH**	**EC**	**Lime**	**OM**	**Sand**	**Clay**	**Silt**	**BD**	**SOC Density**	**TN Density**	**SOC Stocks**	**TN Stocks**
TN	0,684**	1													
C/N	0,331**	-0,297**	1												
pH	0,328**	0,090	0,330**	1											
EC	0,148*	-0,022	0,175*	0,470**	1										
Lime	0,291**	-0,015	0,445**	0,501**	0,380**	1									
OM	0,223**	0,284**	0,017	0,153*	0,291**	0,374**	1								
Sand	-0,271**	-0,053	-0,247**	-0,619**	-0,694**	-0,632**	-0,381**	1							
Clay	0,146*	-0,031	0,187*	0,475**	0,652**	0,402**	0,209*	-0,781**	1						
Silt	0,236**	0,130	0,142	0,332**	0,220**	0,458**	0,323**	-0,523**	-0,120	1					
Db	0,001	-0,109	0,055	0,045	-0,210**	-0,030	-0,189*	0,092	-0,148*	0,045	1				
SOC Density	0,987**	0,651**	0,341**	0,325**	0,120	0,291**	0,194*	-0,260**	0,129	0,241**	0,144	1			
TN Density	0,691**	0,979**	-0,282**	0,100	-0,044	-0,006	0,254**	-0,051	-0,044	0,143	0,076	0,689**	1		
SOC Stocks	0,987**	0,651**	0,341**	0,325**	0,120	0,291**	0,194*	-0,260**	0,130	0,241**	0,143	1,000**	0,689**	1	
TN Stocks	0,691**	0,979**	-0,279**	0,103	-0,045	-0,004	0,253**	-0,052	-0,044	0,145	0,076	0,689**	1,000**	0,689**	1

3.4. Soil Organic Carbon (SOC) and Total Nitrogen (TN) Stocks

In general, while SOC density and SOC stocks changed between 4.00-53.00 mg cm^{-3}, and 1.25-1.59 kg m^{-2}, N density and N stocks varied between 0.09-2.66 mg cm^{-3}, and 0.03-0.80 kg m^{-2}, respectively. According to the mean values of the province, the highest mean SOC density (26.47 mg cm^{-3}), and mean SOC stocks (7.94 kg m^{-2} / 79.4 mg ha^{-1}) were obtained from Karaburun. Karaburun was followed by Menderes > Urla > Tire > Seferihisar > Bergama > Aliaga > Dikili > Kemalpasa > Foca > Torbali > Selcuk > Bayindir > Menemen > Odemis (*Table 3*). The density of SOC expresses the percentage of SOC in a unit of soil volume. According to the classification of Arbeitsgruppe Boden (2005) (*Table 1*), Karaburun, Menderes, Urla, Tire, Seferihisar, Bergama, Aliaga, Dikili, Kemalpasa, Foca, Torbali, and Selcuk were in moderate class, Bayindir, Menemen, and Selcuk were low, Odemis was a very low class in terms of SOC density and SOC stocks. As a result, SOC density and stocks were higher in Karaburun, Menderes, Urla, Tire, and Seferihisar than in the other province, respectively. The climatic condition has an impact on stocks of SOC and TN (Post et al., 1982; Sakin et al., 2011b), and the SOC content reduces by increases in the average temperature (Post et al., 1982; Tremblay et al., 2002; Ganuza and Almendros, 2003; Lemenih and Itanna, 2004; Wang et al., 2004; Sakin et al., 2010). The SOC contents were higher in regions with relatively heavy rainfall in our study. While the precipitation amount of Karaburun, Menderes, Tire, and Seferihisar was 800 mm<, the precipitation amount of Aliaga, Foca, Dikili, Menemen, and the other province were changed between 650-720 mm. In this case, it is clear that as precipitation increases, temperature decreases. High temperatures generally stimulate the decomposition of OM; resulting in SOC decreases. Also, it is known that SOC stock is caused by the texture. For example, at 27 cm depth of soils in Spain, SOC stocks of olive orchards were 34.1 mg ha^{-1} where soils were less clayey and sandier (Parras-Alcantara et al., 2013). SOC stock value was higher than the researchers and its results that the vast majority of olive orchard soils were SL, CL, and SCL textures, in our study. Sand percent had a substantial negative connection with clay ($r=-0.781$), silt ($r=-0.523$), and SOC content ($r=-0.271$), C: N ratio ($r=-0.247$), SOC stocks ($r=-0.260$) ($p<0.01$). Silt percent showed the highest positive significant correlation on SOC stock ($r=0.241$) ($p<0.01$). These findings confirm the previous studies that indicated the role of soil texture in SOC, TN, and C: N ratios. Soil parameters such as SOC and TN were impacted by the mineral composition and textural level of the soil. They are associated with SOC aggregate stability as the clay level rises (Jiao et al., 2012).

This condition affects soil aggregation and clay content, as well as indirectly affects SOC storage by absorbing organic matter from the soil. As a result, soil texture plays a role in chemical and physical preservation mechanisms, either directly or indirectly (Plante et al., 2006). Shortly, clayey soils have high SOC stock values due to the stability mechanisms of the clays in the soil (Burke et al., 1989; Leifeld et al., 2005). Parras-Alcantara et al. (2013) claimed that can be observed this effect in olive orchard soils. The highest mean N density (1.73 mg cm^{-3}) and mean N stocks (0.52 kg m^{-2}) were obtained from Seferihisar. It was followed by Karaburun > Menderes > Menemen > Dikili > Urla > Torbali > Selcuk > Tire > Foca > Aliaga > Bayindir > Bergama > Odemis (*Table 3*). According to the classification of Arbeitsgruppe Boden (2005) (*Table 1*) Seferihisar was high, Karaburun, Menderes, Menemen, Dikili, Urla, Torbali, Selcuk, Tire, Foca, Aliaga, and Odemis were moderate, Bayindir, Bergama was low class. The nitrogen stock level, like the carbon stock content, was higher in Seferihisar, Karaburun, Menderes, and Menemen than in other provinces. It may be caused by high rainfall. Furthermore, temperament and moisture circumstances have little impact on carbon and nitrogen stores. But estimates are done to deal with their effects on carbon for the statement of their relationship with nitrogen (Sakin, 2012). Furthermore, in our investigation, TN concentrations were comparatively high in locations with high SOC, indicating a favorable C: N relationship (*Table 4*). Clay may reduce SOC oxidation, and clay and nitrogen have a beneficial association (Sakin et al., 2011a; 2011b). A study reported that nitrogen mineralization decreases, as the amount of clay in the soil increases (Cote et al., 2000). Clay concentration was directly proportional to aggregate size and accumulation, and the potential N mineralization decreased (McLauchlan, 2006).

4. Conclusions

The very low bulk density is one important qualification of olive orchard soils. These soils have SL, CL, and SCL textures. Bulk density was negatively related to OM and clay level. SOC and soil texture has a very strong correlation, SOC content is increased with increased clay content, and SOC and organic matter content were positively correlated with clay. The sand was negatively correlated by SOC content and SOC stocks, silt showed the highest positive significant correlation with SOC stock. TN concentrations were relatively high in locations with high SOC, indicating a favorable C: N relationship. Rainfall, warmth, soil depths, material migration from high locations to the plains, and soil regeneration are all contributors to the high C and N content. The close C: N ratios are dependent on high resolution and separation levels due to high temperatures, oxidation, and fertilizer application by farmers (which include high levels of nitrogen).

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Ethical Statement

There is no need to obtain permission from the ethics committee for this study.

Conflicts of Interest

We declare that there is no conflict of interest between us as the article authors.

Authorship Contribution Statement

Concept: Deliboran, A.; Design: Deliboran, A.; Data Collection or Processing: Deliboran, A.; Statistical Analyses: Deliboran, A.; Literature Search: Deliboran, A.; Writing, Review and Editing: Deliboran, A.

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