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Carbon and Nitrogen Stocks and C: N Ratio of Harran Plain Soils

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Abstract

Previous studies have focused on carbon (C) and nitrogen (N) stocks of soils because of increases in atmospheric carbon dioxide (CO_2) and terrestrial ecosystems with wide N storages. The goal of this study is to determine C amounts and stocks that are important for global warming, N amounts and stocks and C:N ratios. To this end, 16 series were opened on the Harran Plain and soil samples were taken from 100 cm depth and each horizon. The results showed that average carbon amounts changed between 3.61 and 6.47 kg C m^{-2}. N amounts were between 0.18 and 0.34 kg C m^{-2}, C:N ratios were between 4.34:1 and 6.04:1 and bulk density (BD) was 1.23–1.34 Mg m^{-3}. Carbon and N stocks were determined as 10.53 Tg C and 1.96 Tg N, respectively. Student's t-test was used on all data comparisons and equation determinations, and data were examined at $p<0.05$ and $p<0.01$ importance levels.

Keywords: Carbon cycle, nitrogen cycle, nitrogen, carbon, C:N ratios

Introduction

The importance of the biogeochemical cycles of carbon and nitrogen has increased in terrestrial ecosystems throughout world because their oxidation into the atmosphere plays an important role in global warming maintenance. Soil organic carbon (SOC) is the largest component of terrestrial carbon, and the amount of carbon that exists as SOC is two to three times greater than the carbon present in live vegetation (Post and Kwon, 2000). Moreover, changes in SOC pools can increase the carbon dioxide (CO_2) concentrations in the atmosphere (Smith, 2008). Therefore, understanding soil carbon storage potential and developing effective methods to decrease the atmospheric CO_2 concentration are vitally important (Fu *et al.*, 2010).

Many factors affect the biogeochemical cycle of SOC and therefore also affect SOC stocks and distribution. One of the most important factors is land-use alteration. While converting natural forest areas and meadows to farming areas affects SOC stocks in different ways in different ecosystems and regions (Solomon *et al.*, 2000; Rodriguez-Murillo, 2001; Powers, 2004; Yimer *et al.*, 2007), cultivation and other deformations cause approximately 40 Pg of C loss. Nearly 1.6 Pg C y^{-1} were released in the 1990s (Smith, 2008). Developing non- cultivated agriculture techniques can decreases SOC pool decrease which emerged as a result of natural and forest areas decrease (Puget and Lal, 2005; Grandy and Robertson, 2007).

Soil is one of the most important C and N pools and includes approximately 75% OC and 95% N (Schlesinger, 1997). The interaction between SOC and N is affected by the plants that are present, which affects the ecosystem yield and the terrestrial C cycle. Numerical models of C and N cycles include terms for the climate, the atmosphere and land-use alternation (Homann *et al.*, 2000; Kirschbaum, 2000; Pepper *et al.*, 2005). Jenny (1941) synthesised and summarised the interaction between climate and soil humidity. According to her study, when humidity increases, the N ratio in soil increases in the meadows in the central and eastern United States, but the effects on forests are minor. The N ratio in soil also increases when the temperature increases. Sandy soils contain less mineral–organic C and N than loamy soils. The C:N ratio of sandy soils is higher than that of loamy soils. Similar studies were conducted simultaneously in the central United States (Burke *et al.*, 1989; Franzmeier *et al.*, 1985; Sims and Nielsen 1986), as well as in other parts of the country (Conant *et al.*, 1998; Grigal and Ohmann, 1992; Homann *et al.*, 2004) and in other countries of the world (Hontaria *et al.*, 1999; Paruello, 1998). The results showed differing trends. Although it was expected that SOC would increase with temperature decreases, SOC decreased in southern Oregon (Homann *et al.*, 1995) and Finland forests (Liski and Westman, 1997). Whereas it was expected that SOC and N stocks would increase with precipitation increases (Spain, 1990). These different trends were caused by climate regimes, seasonal weather differences, altitude differences and other factors (Homann *et al.*, 2007).

Biomass accumulates as a result of the autotrophic synthesis of organic compounds on live plants. These processes show that live and dead organic materials contain C and N elements. Because of this relationship, the C:N ratio has been used to characterise live and dead organic matter. Total C accumulation in biomass is generally limited by the effective N (Melillo, 1981; Aber *et al.*, 1989). If the effective N increases, biomass increases and therefore C fixation increases (Mäkipää *et al.*, 1999).

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In studying ecosystem stability, it is important world-wide to determine C:N ratios and create data banks of the results because this ratio serves as an indicator of stability. The goal of this study was to determine the C and N stocks, the C:N ratios and the relationship between C and N in the Harran Plain soils that cover 225 000 ha.

Materials and methods

The Harran Plain is located in the Southeast Anatolia Region, between 38°48′ to 39°12′ E longitude and 37°09′to 36°42′ N latitude, and it covers 225 000 ha in area. Arid and semi-arid soils were opened to irrigation there in 1995. In general, the Harran plains descend to the south; one plain, whose three sides are surrounded with mountains, creating a pot-like appearance, is depicted in Fig. 1. The area between Harran and Akcakale has the lowest elevation. Dinc *et al.* (1998) detected 25 soil series on Harran plain According to the studies of the Soil Survey Staff (1975), FAO/UNESCO (1974) and Dinc *et al.* (1988), the plain soils are of the Entisol, Vertisol and Aridisol soil orders. The soil group details of the Harran plain soils are provided in Tab. 1. Studies showed that the Bellitas (5), İkizce (7) and Cekcek (2) series are of the Entisol order; the Bozyazı (12), Ugurlu (1), Begdes (10), Akcakale (15) and Kısas (4) series are of the Vertisol order; and the Gurgelen (6), Ekinyazı (14), Akoren (13), Irice (9), Harran (11), Kap (16), Sultantepe (3) and Sırrın (8) series are of the Aridisol soil order.

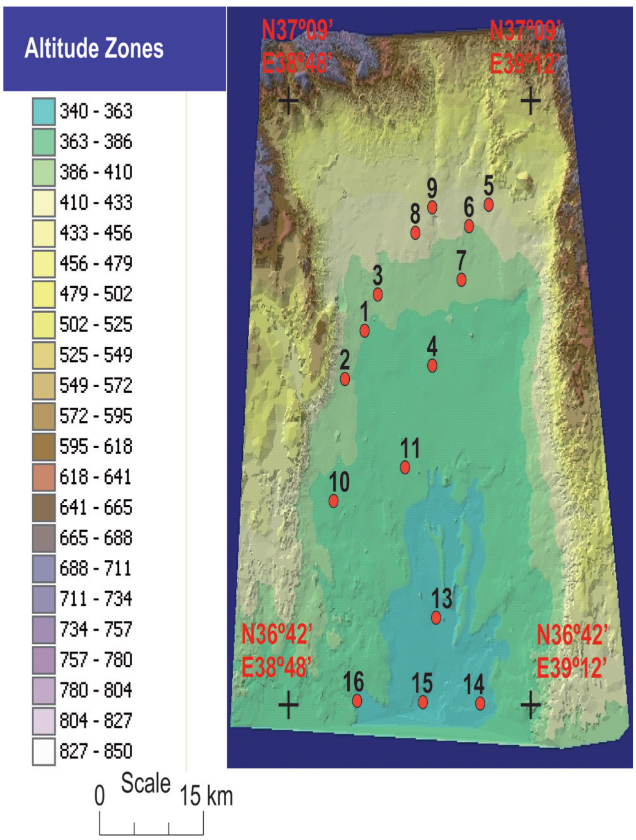

Fig. 1. Location of Harran Plain

Rainfall is nonexistent during most of the year, and the climate is arid. According to 33 years of data (1975–2008) from the Turkish State of Meteorology Service (TSMS), the average annual precipitation is 277.8 mm at Akcakale station and 448.1 mm at Sanlıurfa station. Specifically, while precipitation is low in Akcakale, the southernmost point, it reaches up to 450 mm on the northward foot of the Sanlıurfa mountains. The soil moisture regime of important parts of the plain is Xeric, and the temperature regime is Mesic. Specifically, an Aridic soil humidity regime is seen in parts of the areas near the south of the plain (Soil Survey Staff, 1996).

In addition to being deficient in rain during most of year, the plain also experiences high temperatures for long periods of time. As Tab. 1 shows, there is little precipitation between May and October, and temperature and evaporation are high when rainfall is low. The evaporation rate increases from the foot of the Urfa mountains to Ak-

Tab. 1. Soil taxonomy of Harran Plain soils (SSS, 1975; FAO / UNESCO, 1974; Dinc *et al.*, 1988)

Soil taxonomy				Soil series	FAO/ UNESCO
Ordo	Subordo	Great group	Subgroup		
Entisol	Fluvent	Torrifluvent	Vertic Torrifluvent	Ikizce	Calcaric Fluvisol
			Typic Torrifluvent	Bellitas	
				Cekcek	
				Urfa	
	Orthent	Torriorthent	Lithic Torriorthent	Fatik	Litosol
Vertisol	Torrert	-------	Typic Torrert	Begdes	Chromic Vertisol
				Bozyazi	
				Akcakale	
				Kısas	
			Paleustollic Torrert	Ugurlu	
Aridisol	Orthid	Gypsiorthid	Typic Gypsiorthid	Cepkenli	Gypsic Xeresol
		Paleorthid	Typic Paleorthid	Gulveren	
				Kap	
		Calciorthid	Typic Calciorthid	Meydankapi	Calcic Xeresol
				Gundas	
				Hancigaz	
				Ekinyazi	
				Akoren	
				Irice	
				Gurgelen	
				Sultantepe	
			Vertic Camborthid	Harran	
				Karabayir	
				Sirrin	
		Camborthid	Typic Camborthid	Konuklu	Haplic Xeresol

Tab. 2. Mean climate values of Sanliurfa and Akcakale stations (TSMS, 2008)

	January	February	March	April	May	June	July	August	September	October	November	December	Mean
Precipitation (mm) (Akcakale)	47.39	45.83	40.46	27.56	17.24	0.99	0.81	0.47	18.79	33.05	47.38	47.39	277.81
Precipitation(mm) (Centre)	77.21	78.36	65.55	44.41	27.51	3.52	0.79	1.06	0.91	27.58	49.88	75.31	448.11
Evaporation(mm)	-	-	61.80	119.60	203.10	332.80	421.10	421.10	291.90	291.90	59.30	-	2022.80
Average Temperature (°C)	4.90	6.60	10.30	17.80	23.10	29.20	34.80	31.30	26.40	19.10	14.40	8.00	18.80
Minimum Temperature (°C)	-2.40	-1.50	-0.60	6.10	10.60	18.50	22.70	20.40	13.80	9.40	5.70	1.00	8.650
Maximum Temperature (°C)	20.50	16.60	25.50	29.60	35.30	40.00	46.80	43.00	38.20	31.60	26.20	18.00	25.00
Average Relative Humidity (%)	74.30	63.00	55.20	56.80	41.00	36.70	33.40	43.00	46.10	54.40	52.90	71.70	52.40
5 cm Average Soil Temperature (°C)	5.60	7.60	11.70	19.70	27.40	34.70	39.80	37.20	31.30	22.40	14.50	8.10	21.70
10 cm Soil Temperature (°C)	6.00	7.60	11.40	19.20	26.10	32.50	37.40	35.80	30.80	22.80	15.30	8.60	21.10

cakale. The seasonal average precipitation is highest in the winter months and lowest in the summer season.

Soil samples were taken from 16 series of genetic horizons on the Harran Plain. The soil samples were dried at room temperature and passed through a 2 mm sieve prior to analysis. The bulk density (BD) (Mg m^{-3}) was determined according to Black (1965). The organic carbon content was estimated by titrating the samples boiled with sulphuric acid and Fe_2SO_4 (Walkely and Black, 1934). The SOC (kg C m^{-2}) stock was calculated according to Batjes (1996). The nitrogen content was analysed using the micro-Kjeldahl method (AOAC, 1990). The samples were read on a device that was set at 85°C (FP 526 LC, LECO). The total nitrogen stock (Kg N m^{-2}) was computed with the method that was used for calculating the SOC stock. Student's t-test was used on all of the data comparisons and equation determinations and the data were examined at $p<0.05$ and $p<0.01$ significance levels.

Results

Soil organic carbon stocks

The SOC amounts and stocks, the N amount and stocks, and the BD were determined at 100 cm depths of Harran plain soils. The bulk density varied between 1.23-1.34 Mg m^{-3} (Tab. 3).

The SOC content was at its lowest in the Harran series (3.57 kg C m^{-2}) and at its maximum level in the Sırrın series (6.47 kg C m^{-2}). The total carbon amounts changed between 3.57 and 6.47 kg C m^{-2}. The carbon amounts of the other series varied significantly ($p<0.05$) and are shown in Tab. 4. The organic carbon stock of the Harran plain was 10.53 Tg C. The organic carbon contents were higher on the northern side where precipitation was high. It is commonly known that, in general, temperature decreases as precipitation increases. High temperatures generally accelerate organic matter decomposition; hence, SOC decreases. Whereas the precipitation amount was 277 mm in the southern region, it was nearly 450 mm in the north. Therefore, carbon amounts were lower in the southernmost Akcakale series than in the northern Sırrın series. The carbon content of the plain was higher than that expected of an arid or semi-arid region because of increased soil depth, movement and accumulation of surface materials from high areas to the plain, high clay content (45-73%), too much calcareousness, and the constant rejuvenation of the plain soils.

Total nitrogen stocks

The total nitrogen contents were between 0.72 and 1.07 kg N m^{-2}, with the lowest content occurring in the Akcakale series and the highest content occurring in the Sırrın series. The nitrogen amounts of the other series are represented in Tab. 5. The total N stock was 1.96 Tg N on the Harran plain. The nitrogen content, like the carbon content, was higher in the northern profiles than in the southern profiles. It is hypothesised that the reason for this is high precipitation. Although it is known that the Harran plain soils are too clay, the effects of clay on nitrogen stocks are not known. There are no studies examining the texture-nitrogen relationship on the Harran plain. While it is estimated that when clay amount increases, nitrogen mineralization this phenomenon has not been confirmed. Generally, concentrations of nitrogen are high in areas where the SOC is high. This shows a positive C:N rela-

Tab. 3. Statistical distribution of bulk density (mg m^{-3})

Soil series[a]	N	Mean	Minimum	Median	Maximum	CV[b]
Ugurlu	10	1.23	1.20	1.25	1.25	1.87
Cekcek	10	1.27	1.25	1.26	1.29	1.30
Sultantepe	10	1.30	1.27	1.30	1.32	1.38
Kisas	10	1.29	1.27	1.29	1.31	1.15
Bellitas	10	1.31	1.29	1.31	1.31	0.68
Bozyazi	10	1.30	1.29	1.31	1.33	2.55
İkizce	10	1.30	1.28	1.29	1.31	1.04
Sirrin	10	1.31	1.30	1.31	1.31	0.42
Irice	10	1.30	1.28	1.29	1.31	1.04
Begdes	10	1.32	1.30	1.33	1.33	1.25
Harran	10	1.31	1.30	1.31	1.31	0.42
Gurgelen	10	1.33	1.31	1.33	1.34	1.14
Akoren	10	1.34	0.75	1.33	1.34	1.35
Ekinyazi	10	1.34	1.31	1.35	1.35	1.34
Akcakale	10	1.32	1.31	1.33	1.33	0.68
Kap	10	1.34	1.33	1.34	1.34	0.33

[a]Soil series are listed by Dinc *et al.* (1988); [b]CV is the coefficient of variation (%)
[c]Depth soil of 100 cm; N is the number of observations

Tab. 4. Carbon amounts of Harran plain soils (kg C m^{-2})

Soil series[a]	N	Mean	Minimum	Maximum	CV[b]	Total SOC[c]
Ugurlu	10	1.14	0.78	1.47	22.38	4.62
Cekcek	10	0.80	0.57	0.93	19.90	4.03
Sultantepe	10	0.97	0.43	1.47	43.87	4.84
Kisas	10	1.01	0.29	1.76	67.14	4.75
Bellitas	10	1.38	0.56	1.96	45.99	4.94
Bozyazi	10	1.23	0.94	1.64	21.75	5.04
Ikizce	10	1.44	0.79	1.98	39.71	5.22
Sirrin	10	1.85	0.91	2.79	47.71	6.47
Irice	10	1.54	1.21	1.86	19.76	5.85
Begdes	10	1.16	0.34	1.98	69.40	5.45
Harran	10	0.85	0.63	1.26	29.79	3.57
Gurgelen	10	0.87	0.58	1.21	32.33	3.78
Akoren	10	1.00	0.89	1.21	12.17	4.06
Ekinyazi	10	1.72	1.06	2.16	34.63	4.31
Akcakale	10	1.26	0.80	1.46	20.81	3.61
Kap	10	1.44	1.21	1.62	10.20	4.29

[a]Soil series are listed by Dinc *et al.* (1988); [b]CV is the coefficient of variation (%); [c]Depth soil of 100 cm total SOC; N is the number of observations

Tab. 5. Nitrogen content of Harran plain of soils (kg N m^{-2})

Soils series[a]	N	Mean	Minimum	Maximum	CV[b]	Toplam N[c]
Ugurlu	10	0.21	0.14	0.28	24.13	0.85
Cekcek	10	0.16	0.13	0.18	11.87	0.81
Sultantepe	10	0.19	0.12	0.26	27.85	0.94
Kisas	10	0.21	0.14	0.30	32.99	0.91
Bellitas	10	0.25	0.10	0.35	45.74	0.88
Bozyazi	10	0.29	0.16	0.28	19.80	0.94
Ikizce	10	0.26	0.14	0.37	42.11	0.93
Sirrin	10	0.32	0.15	0.49	51.30	0.97
Irice	10	0.26	0.20	0.33	23.29	0.99
Begdes	10	0.22	0.11	0.34	51.20	0.98
Harran	10	0.19	0.11	0.25	27.57	0.73
Gurgelen	10	0.18	0.14	0.24	23.97	0.76
Akoren	10	0.20	0.17	0.23	11.75	0.78
Ekinyazi	10	0.34	0.19	0.44	40.27	0.81
Akcakale	10	0.26	0.15	0.30	24.79	0.72
Kap	10	0.30	0.23	0.33	14.91	0.85

[a]Soil series are listed by Dinc *et al.* (1988); [b]CV is the coefficient of variation (%) [c]Depth soil of 100 cm total N; N is the number of observations

tionship. According to this relationship, clay decreases SOC oxidation. Hence, it is hypothesised that there could be a positive relationship between clay and nitrogen. Moreover, there is little effect of temperature and humidity parameters affecting carbon stocks on nitrogen stocks. However, to explain their relation with nitrogen, guesses are done related to their effects on carbon.

Carbon/nitrogen (C:N) ratios

The carbon:nitrogen ratios were important ($p<0.01$) in all series throughout the profile (100 cm). The average

Tab. 6. C:N ratios of Harran plain soils (kg m^{-2})[c]

Soil series[a]	N	Mean	Minimum	Maximum	CV[b]
Ugurlu	10	5.48	5.22	5.75	4.06
Cekcek	10	5.03	3.24	5.65	20.02
Sultantepe	10	5.08	2.62	5.78	27.09
Kisas	10	4.32	2.16	5.81	45.63
Bellitas	10	5.64	5.58	5.78	1.38
Gurgelen	10	5.17	4.27	5.81	15.97
Ikizce	10	5.61	5.37	5.78	3.91
Sirrin	10	6.04	5.75	6.30	4.43
Irice	10	5.87	5.68	6.33	4.91
Begdes	10	4.77	3.04	6.01	33.13
Harran	10	4.70	3.56	5.71	22.97
Bozyazi	10	4.80	4.01	5.58	15.18
Akoren	10	5.14	4.78	5.51	6.59
Ekinyazi	10	5.25	4.91	5.75	8.77
Akcakale	10	4.84	4.45	5.58	11.23
Kap	10	4.80	4.37	5.71	12.90

[a]Soil series are listed by Dinc *et al.* (1988); [b]CV is the coefficient of variation (%); [c]Depth soil of 100 cm; N is the number of observations

C:N ratios of all of the series were ordered as follows: Sırrın > Irice > Bellitas > Ikizce > Begdes > Ugurlu > Gurgelen > Ekinyazi > Akoren > Kısas > Sultantepe > Akcakale > Kap > Bozyazi > Cekcek > Harran (Tab. 6). The C:N ratios were generally high in areas where the altitude, the vegetation and the precipitation were high. The C:N ratio was similar in the plain soils. This shows that the resolution and separation amounts are high. Moreover, the application of too much nitrogen fertiliser may have narrowed this ratio. A highly significant relationship existed between carbon and nitrogen contents ($r = 0.9973$; $p<0.01$) (Fig. 2).

The C:N ratios ranged between 5.38:1 and 6.33:1 in surface soils (0–20 cm). There was not much variation among the C:N ratios of the plain soils, which may be due to the similar climatic conditions and the agriculture management techniques adopted by the farmers. However, the small differences in the C:N ratios may also be due to variations in the microclimatic conditions, especially the temperature and the quantity and distribution of precipitation.

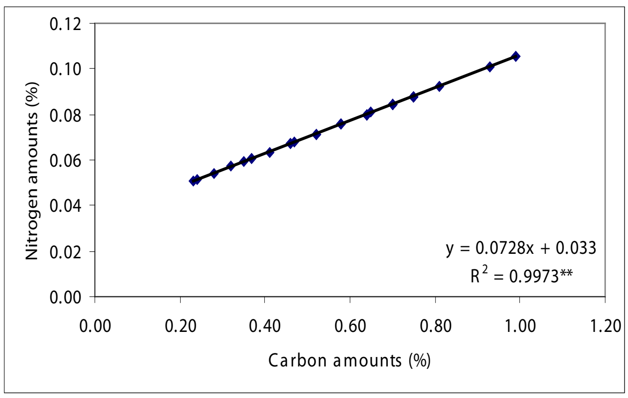

Fig. 2. Relationship between carbon and nitrogen

Discussion

In this study, a small difference was observed between SOC and total N stocks and C:N ratios of Harran Plain soils in the north-to-south direction. Average carbon stocks were slightly higher on the northern side than on the southern side, which may be due to higher precipitation on the northern portion than on the southern portion of the plain (450 mm vs. 277 mm). Furthermore, high precipitation caused temperatures to decrease to some extent. This corroborates the observation that the SOC content decreases with increases in the annual temperature, as reported by Post *et al.* (1982), Tremblay *et al.* (2002), Ganuza and Almendros (2003), Lemenih and Itanna (2004), Wang *et al.* (2004) and Sakin (2010). According to Yimer *et al.* (2006) and Sakin *et al.* (2010a:b:c), the SOC stocks increase based on annual precipitation and biomass amounts and decrease relative to temperature. Soil C and N stocks are affected by climate (Post *et al.*, 1982). In line with several earlier studies (Bationa and Buerkert, 2001; Yimer *et al.,* 2006; Moges and Holden, 2008; Fu *et al.,* 2010), a very strong relationship between C and N was observed in this study.

It is hypothesised that clay and calcareous plain soils retain high amounts of carbon and nitrogen, but there are different theories regarding the effect of the clay concentration in soil on the SOC accumulation. An increase in maximum and average SOC content with increased soil clay content has been reported from a few Great Plains sites (Nichols, 1984; Burke, 1989). However, this phenomenon cannot be generalised as other factors like soil aluminum, extractable allophone content or specific surface area can also influence the SOC content (Percival *et al.*, 2000; Krull *et al.*, 2003). The relationship between the clay concentration and the SOC content is strong when they are compared in soil organic matter (SOM) models like Century (Parton *et al.*, 1987) and RothC (Jenkinson, 1990), which state that the SOM resolution decreases when the clay concentration increases. Wang *et al.* (2003) explains that clay has no effect on the first stage of soil occurrence but that it can be effective at the later stages. Muller and Hoper (2004) reveal the different effects of clay on carbon resolution. McLauchlan (2006) argues that no strong relationship between clay and carbon resolution has been observed.

The total N amounts and stocks are high on the northern portion of the Harran plain. The high nitrogen content is probably due to the high SOC content. The main reason for this is high precipitation; Ganuza and Almendros (2003) verify this theory. The clay content of the plain soil is high. Although the effect of clay on nitrogen stocks and amounts is unknown, a positive relationship is predicted. Some studies (Cote *et al.*, 2000) state that the net N mineralisation decreases when the clay amount increases in the soil, but other studies (Giardina *et al.*, 2001) have found that the effect of clay on the net N mineralisation is low under different temperature and humidity conditions in the laboratory. McLauchlan (2006) explains that when clay amounts increase in soil, aggregate amounts increase dramatically and the potential net N mineralisation decreases. Whatever the age of the field, each 10% increase in clay concentration increases the aggregate size index by 0.039 and decreases the net N mineralisation by 0.16 kg ha^{-1} day^{-1}.

The total nitrogen range (0.72-1.07 kg N m^{-2}, in 100 cm depth) observed was similar to those observed in several previous studies. Carter *et al.* (1998) reported a total nitrogen range of 0.36-1.05 kg N m^{-2} in Canada farming soils. Zinke and Stangenberger (2000) found 0.61 kg N m^{-2} in Sierra shallow cone forests and 0.27 kg N m^{-2} in Nevada forests. Other nitrogen ranges observed include 0.5 kg N m^{-2} in mineral soils (Vejre *et al.*, 2003), 0.21-3.13 kg N m^{-2} in Amazon soils (Dijkshoorn, 1999), 1.39 kg N m^{-2} in Podzol (Spodosol) soils, 1.03 kg N m^{-2} in Luvisoller (Alfisol) soils, 0.52 kg N m^{-2} in Arenosoller (Entisol) soils (Batjes, 1996), 0.17-0.29 kg N m^{-2} (Fu *et al.*, 2010) and 0.05–1.65 kg N m^{-2} (Callesen *et al.*, 2007). According to Callesen *et al.* (2007), N is higher in calcareous soils (1.12 kg N m^{-2}) than in fine-textured soils (0.62 kg N m^{-2}) and medium-and coarse-textured soils (0.51 and 0.48 kg N m^{-2}). In the research area, the Bellitas, Ikizce and CekCek series (Entisol) include, respectively, 0.81, 0.88 and 0.93 kg N m^{-2}; these amounts are high when compared with the Batjes (1996) studies and normal when compared with Batjes and Dijkshoorn (1999) study. It is hypothesised that this is based on high precipitation and soils that are calcareous and contain too much clay.

The C:N ratio in the surface soil was higher than that in lower portions of the subsurface soil horizons. This indicates high resolution and separation rates. Furthermore, it is thought that extreme cultivation techniques affect the C:N ratios. The C:N ratios varied between 4.86:1 and 6.02:1. Lal *et al.* (1995) indicated that C:N ratios are low during resolution and separation times. Brady and Weil (2008) showed that C:N ratios varied between 8:1 and 15:1, with an average of 12:1. Batjes (1996) determined (at a depth of 100 cm) that the lowest average C:N ratio was 7:1 in Xerosols and that the highest average C:N was 24.5:1 in Podzols. Although the C:N ratios in this study showed similarities to the Batjes (1996) findings, this study's ratios were lower. It is hypothesised that this phenomenon was caused by low precipitation, high resolution and separation rates and extreme cultivation techniques. Whereas the C:N ratio increases with precipitation, it decreases with higher temperatures (Miller *et al.*, 2004). Other researchers argue that there is a positive relationship between C:N ratios, precipitation and temperature (Callesen, 2007). It is argued that although the cultivation systems and farming activities used 10 years ago did not affect C:N ratios (Sainju *et al.*, 2008; Fu *et al.*, 2010), today's farming techniques and agriculture do affect C:N ratios (Puget and Lal, 2005; Yimer *et al.*, 2007).

Conclusions

Carbon amounts and stocks, N amounts and stocks and C:N ratios of plain soils are generally higher than similar environments. The reasons for the high C and N contents are precipitation, high clay and calcareous contents, soil depths, material movement from high areas to the plains and soil regeneration. The close C:N ratios are based on high resolution and separation amounts because of high temperatures, oxidation and fertiliser usage by farmers, which contain high levels of nitrogen.

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