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Soil Organic Matter Mineralization under Different Temperatures and Moisture Conditions in Kızıldağ Plateau, Turkey

(Pemineralan Jirim Tanah Organik di Bawah Suhu dan Lembapan Berbeza di dataran Penara Kızıldağ, Turki)

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ABSTRACT

Drought by climate change in East Mediterranean Region will change soil temperature and moisture that lead to alter the cycling of biological elements like carbon and nitrogen. However, there are few studies that show how sensitivity of soil organic matter mineralization to temperature and/or moisture can be modified by changes in these parameters. In order to study how these changes in temperature and moisture affect soil carbon and nitrogen mineralization, a laboratory experiment was carried out in two depths (0-5 and 5-15 cm) of soils of Onobrychis beata *and* Trifolium speciosum *being common annual plants in Turkey that was taken from Kızıldag Plataeu (Adana city). Some soil physical and chemical properties and as well as rate of carbon and nitrogen mineralizations were determined for both depths of soils. These soils were incubated for 42 days under different field capacities (FC 60, 80 and 100%) and temperatures (24, 28 and 32°C). Cumulative carbon mineralization (C_m), potential mineralizable carbon (C_0) and rate of carbon mineralization of all soils were increased with rising temperatures. Rate of carbon mineralization in* O. beata *soil were lower than* T. speciosum *soil. NH_4-N and NO_3-N contents at 42nd day were higher than initial levels of soils and also increased with temperatures and field capacities. In summary, sensitivity of soil organic matter mineralization to temperature was higher at 32°C in upper layer and lower at 24°C in deeper layer of both soils.*

Keywords: Climate change; East Mediterranean Region; incubation experiment; soil C and N mineralization

ABSTRAK

Kemarau yang disebabkan oleh perubahan iklim di Rantau Mediterranean Timur akan mengubah suhu tanah dan lembapan yang membawa kepada perubahan kitaran unsur biologi seperti karbon dan nitrogen. Walau bagaimanapun, terdapat beberapa kajian yang menunjukkan bagaimana sensitiviti pemineralan jirim tanah organik ke atas suhu dan/atau lembapan boleh diubah suai melalui perubahan kepada parameter ini. Dalam usaha untuk mengkaji bagaimana perubahan dalam suhu dan lembapan mempengaruhi karbon tanah dan pemineralan nitrogen, uji kaji makmal telah dijalankan pada dua kedalaman (0-5 dan 5-15 cm) daripada tanih Onobrychis beata *dan* Trifolium speciosum *yang merupakan tumbuhan biasa di Turki yang telah diambil dari Penara Kızıldag (bandar Adana). Beberapa sifat fizikal dan kimia tanah serta kadar pemineralan karbon dan nitrogen telah ditentukan bagi kedua-dua kedalaman tanah. Tanah ini telah dieram selama 42 hari di bawah kapasiti bidang yang berlainan (FC 60, 80 dan 100%) dan suhu (24, 28 dan 32°C). Pemineralan karbon kumulatif (C_m), potensi karbon boleh dimineral (C_0) dan peningkatan kadar pemineralan karbon untuk semua tanah dengan peningkatan suhu. Kadar pemineralan karbon dalam tanah* O. beata *adalah lebih rendah daripada tanah* T. speciosum. *Kandungan NH_4-N dan NO_3-N pada hari ke-42 adalah lebih tinggi daripada tanah peringkat awal dan meningkat dengan suhu dan kapasiti lapangan. Kesimpulannya, sensitiviti pemineralan jirim tanah organik kepada suhu adalah lebih tinggi pada 32°C dalam lapisan atas dan 24°C pada lapisan bawah untuk kedua-dua tanah.*

Kata kunci: Pemineralan tanah C dan N; perubahan iklim; Rantau Mediterranean Timur; uji kaji inkubator

INTRODUCTION

Effects of global climate changes to the soils are a popular topic in scientific community. Climate change will affect all ecological processes in soil that is based on soil temperature, moisture and therefore soil organic matter mineralization (Curtin & Campbell 2008; Hopkins 2008; Kirschbaum 2000). These factors particularly affect the biological activity of soil, thus the emission of CO_2 that mainly causes the greenhouse effect and as a result also causes global climate change (Cox et al. 2000; Komala & Khun 2014). While solar energy fixed by plants through photosynthesis is released by respiration of living organisms, much of it is stocked in organic matter until respired by decomposing microorganisms (Olson 1963). Soil physical, chemical and biological properties, climatic factors and quality of soil organic carbon determines the rate of organic matter decomposition (Kirschbaum 2000; Mande et al. 2014). Prediction of organic matter dynamics under future climate scenarios are based on researching the sensitivity of carbon mineralization to soil temperature and moisture in recent years. More measurements of how carbon mineralization affected by these parameters are needed to enhance the accuracy of present simulation models for predicting effects of climate change on terrestrial ecosystems (Rey et al. 2005). For these reasons, incubation of soils under controlled conditions like constant temperature or moisture is the most accurate and reliable method to study carbon and nitrogen mineralization for these predictions (Guntinas et al. 2013; Kirschbaum 2000; Zengin et al. 2008).

Summer droughts that affect mostly the upper soil layers are the main character of the Mediterranean climate and recently, NASA (National Aeronautics and Space Administration) reported that drought in the East Mediterranean region is drier than the last 900 years with possibility of 89% (Cook et al. 2016). However, particular data for effects of soil temperature and moisture on soil organic matter mineralization in the Mediterranean region are rare (Neffar et al. 2015; Rey et al. 2005). Guntinas et al. (2013) also claimed that there were not any knowledge about how soil moisture or combined with temperature affects soil organic matter decomposition.

Based on these findings, recent changes in global climate may possibly affect soil microbial activity through both carbon and nitrogen mineralizations by changes in soil moisture and temperatures at different soil depths in East Mediterranean Region of Turkey. We hypothesized that: increase in soil temperatures will increase both carbon and nitrogen mineralizations; increase in soil moistures will change soil microbial activity; and both interaction effects of temperature and moisture will stimulate both C and N mineralizations and there will be increase in decomposition of soil organic matter in both depths of soils (0-5 and 5-15 cm). Therefore, the aim of the this study was to conduct soil incubation experiements under different temperatures (24°C, 28°C and 32°C) and humidities (60%, 80% and 100% of FC (field capacity)) *in vitro* over 42 days.

MATERIALS AND METHODS

STUDY SITE AND SOIL ANALYSES

Soils of *Onobrychis beata* Sirj. (Endemic) and *Trifolium speciosum* Willd. (Widespread) were taken from Kızıldağ Plateau (1500 m; 37˚24'N; 34˚52' E) in Karaisalı district of Adana, Turkey (mean annual precipitation and temperature of 897.3 mm and 18.3°C) characterized by the semiarid Mediterranean climate conditions (Keskin 2014).

Three superficial soil samples from the upper 0-5 and 5-15 cm of both plant were collected from three corners of each plot (approximately 100 m^2) in August 2013. The soils were mixed homogenized and considered as a composite and representative sample and then sieved a 2 mm mesh sieve, plant debris were removed. Soil texture was determined by Bouyoucos hydrometer (Bouyoucos 1951), field capacity (%) by 1/3 atmospheric pressure with a vacuum pump (Demiralay 1993), pH by a 1:2.5 soil-water suspension with pH-meter (inoLab pH/Cond 720, WTW GmbH, Weilheim, Germany) (Jackson 1958). Total organic carbon (TOC) and total nitrogen (TN) contents of soils (%) were determined by modified Walkley and Black method and Kjeldahl method, respectively (Duchaufour 1970). Three replicates were used for each analysis.

CARBON AND NITROGEN MINERALIZATIONS

Soils were placed in 750 mL incubation vessels for carbon mineralization. The moisture contents of soils at mineralization measurements of both 0-5 and 5-15 cm depths were adjusted to 60, 80 and 100% of field capacity before incubation at 24°C, 28°C and 32°C (Schaefer 1967). CO_2 derived from microbial activities were absorbed in 40 mL saturated $Ba(OH)_2$ solution in beakers, placed in the center of the soils, in closed incubation vessels and then transferred to an incubator. The amount of CO_2 produced was measured once in 3 days by titration with oxalic acid (Benlot 1977). Empty vessels were used as blanks and three replicates were used for all treatments. Cumulative C mineralization (mg $C(CO_2)$/100 g soil) was calculated by summing up all 3 d CO_2 until end of incubation period while its rate was calculated by dividing cumulative mineralized C by its soil organic C of control and all applications for 42 days. Relationship between the cumulative C mineralization quantity and incubation time in all treatments were simulated by using the first-order exponential equation: $C_m = C_0 (1 - e^{-kt})$ (Ajwa & Tabatabai 1994). C_m (CO_2-C mg·100 g^{-1} soil) is amount of C mineralized through incubation period (days) while C_0 (CO_2-C mg·100 g^{-1} soil) is quantity of soil potentially mineralizable C and k (day^{-1}) is mineralization rate constant.

Soil samples were placed in 750 mL incubation vessels at different temperatures (24°C, 28°C and 32°C) and moistures (60, 80 and 100% of FC) before incubation for nitrogen mineralization. The vessels covered with gauze for aeration were weighed three times every week to determine any weight loss. Distilled water was added when necessary to maintain soil moisture during 42 days. At 1st and 42nd days, amount of mineral nitrogen (NH_4-N + NO_3-N) were measured in soils to calculate nitrogen mineralization rate. All soil samples were mixed separately with 200 mL 1 N $CaCl_2$ solution and shaken for 1 h strained samples were distilled to measure mineral nitrogen by the Parnas-Wagner method (Gökceoglu 1979; Lemée 1967). The rate of nitrogen mineralization was calculated by dividing total amount of mineral nitrogen by total nitrogen (Guleryuz & Everest 2010).

STATISTICAL ANALYSIS

Some soil physical and chemical properties were analyzed by a series of one-way ANOVA. Two-way ANOVA was used to test the effects of the temperature, soil moisture and their interactions on soil carbon and nitrogen mineralization in different soil depths of both soils. (Kleinbaum et al. 1998). The coefficients of the first-order kinetic model (C_0 and k) were calculated (Origin v.8.0). Three replicates were used for each application for statistical comparisons. All of the tests were performed at the significance level of $p<0.05$. Statistical analysis was carried out using SPSS v20.

RESULTS

All soils were loam textured and slightly alkaline. There were significant differences between texture and pH in each soil depths ($p<0.05$). Field capacities were in the range of 21.5 - 28.4%. Total organic carbon (TOC) contents were between 1.69 and 5.33%, whereas total nitrogen (TN) contents were 0.14 - 0.33%. C/N of soils were between 11.2 and 16.2. Generally, C and N contents were higher at 0-5 cm depth than at 5-15 cm in all soils ($p<0.05$) (Table 1).

Cumulative carbon mineralization of all soils (C_m) were increased with rising temperatures and highest C_m was observed in FC 80% in all soils within all temperatures (FC 80% > FC > FC 60%) (Figure 1). Following data includes comparisons between 3 field capacities for each temperature and between 3 temperatures at each field capacities for each plant, separately. In 0-5 cm depth of *Onobrychis* soil, there were significant differences between FC 60% and others ($p<0.05$) at 24°C, FC 60% and FC 80% ($p=0.007$) at 28°C and all field capacities ($p=0.000$) at 32°C. In 5-15 cm depth of *Onobrychis* soil, statistically significant differences were found between all field capacities ($p\leq0.001$) at 24°C, FC 60% and others ($p<0.05$) both at 28°C and at 32°C (Figure 1). On the other hand, in 0-5 cm depth of *Trifolium* soil, there were significant differences between FC 60% and others ($p<0.05$) at 24°C, all field capacities ($p<0.05$) at 28°C and ($p\leq0.001$) at 32°C. In 5-15 cm depth of *Trifolium* soil, significant differences were found between FC 60% and others ($p<0.05$) at 28°C, FC 60% and FC 80% ($p=0.035$) at 32°C but no difference were found between all field capacities at 24°C (Figure 1).

Cumulative carbon mineralization of applied temperatures statistically was different at each field capacity. In 0-5 cm depth of *Onobrychis* soil, there were significant differences between 24°C and 28°C ($p=0.015$), in FC 60%, 28°C and 32°C ($p<0.05$) at FC 80% and 100% while there were only between 28°C and 32°C in all field capacities ($p<0.05$) in the same depth of *Trifolium* soil. However, at 5-15 cm depth of both soils there were found no significant differences between temperatures in all field capacities except for between 24°C and 28°C ($p=0.009$) and 32°C ($p= 0.009$) in FC in 5-15 cm of *Onobrychis* soil (Figure 1).

Carbon mineralization rate of *Onobrychis* was lower than *Trifolium* in all applications because *Onobrychis* soil had more organic carbon content than *Trifolium* soil (Figure 2). In contrast, carbon mineralization ratio generally was lower at 0-5 cm depth than 5-15 cm depth of both soils. Because of no changes in TOC in all applications, statistical differences between carbon mineralization rates were found the same as C_m (Figure 2).

Carbon mineralization is significantly affected by the interactive effects of temperature and field capacity in 0-5 cm depth of both soils ($p=0.011$ for *Onobrychis*, $p=0.002$ for *Trifolium*) but no interaction found in 5-15 cm of both soils ($p>0.05$) (Table 2).

The kinetic parameters of C mineralization obtained from the first order kinetic model ($Cm = C_0(1 - e^{-kt})$) have been reported in Table 3. Potential mineralizable C (C_0) in all soils was also increased with an increase in temperatures in the same way of C_m and lowest C_0 values were found in FC 60% at 24°C while it was highest in FC 80% at 32°C. C_0 was ranged from 12.79-21.81 mg CO_2-C 100 g^{-1} in 0-5 cm depth and 12.95 - 20.95 mg CO_2-C 100 g^{-1} in 5-15 cm depth of *Onobrychis* soil while it was in the range of 14.32-24.67 mg CO_2-C 100 g^{-1} in 0-5 cm depth and 14.29-20.92 mg CO_2-C 100 g^{-1} in 5-15 cm depth of *Trifolium* soil. But k values were variable in all soils (Table 3).

Generally, NH_4-N and NO_3-N contents at 42nd day were higher than initial levels of soils (1st day) and also increased with temperatures and field capacities (Table 4). Significant differences between applications for mineral nitrogen contents were denoted as different letters in Table 4. Also in general, NH_4-N contents of *Onobrychis* soil were different at 0-5 cm than at 5-15 cm depth while NO_3-N contents were similar in all applications in both depths (Table 4). In contrast, both NH_4-N and NO_3-N contents of *Trifolium* soil generally increased with depth (Table 4). Nitrogen mineralization is also significantly affected by the interactive effects of temperature and field capacity in all depths of both soils except at 5-15 cm of *Trifolium* soil

TABLE 1. Some soil properties of *Onobrychis beata* and *Trifolium speciosum* (mean ±SE, $n=3$)

Characteristics	*Onobrychis beata*		*Trifolium speciosum*	
	0-5 cm	5-15 cm	0-5 cm	5-15 cm
Sandy (%)	42.41 ± 0.37 b	39.43 ± 0.40 c	47.76 ± 0.55 a	41.39 ± 0.48 bc
Clay (%)	19.85 ± 0.31 b	25.53 ± 0.52 a	12.14 ± 0.24 d	14.67 ± 0.27 c
Silt (%)	37.74 ± 0.07 c	35.04 ± 0.25 d	40.10 ± 0.36 b	43.94 ± 0.49 a
Texture type	Loam (L)			
FC (%)	28.36 ± 0.21 a	24.00 ± 0.47 b	21.50 ± 0.68 c	22.14 ± 0.27 bc
pH	7.52 ± 0.01 b	7.31 ± 0.01 c	7.61 ± 0.01 a	7.12 ± 0.01 d
SOC (%)	5.33 ± 0.09 a	2.94 ± 0.04 b	2.06 ± 0.03 c	1.69 ± 0.03 d
TN (%)	0.33 ± 0.01 a	0.26 ± 0.01 b	0.18 ± 0.01 c	0.14 ± 0.01 d
C/N	16.16 ± 0.51 a	11.17 ± 0.22 b	11.69 ± 0.35 b	12.10 ± 0.30 b

Different letters in the same row indicate significant differences ($p<0.05$). FC: Field capacity, SOC: Soil organic carbon, TN: Total nitrogen C/N: Ratio of C/N

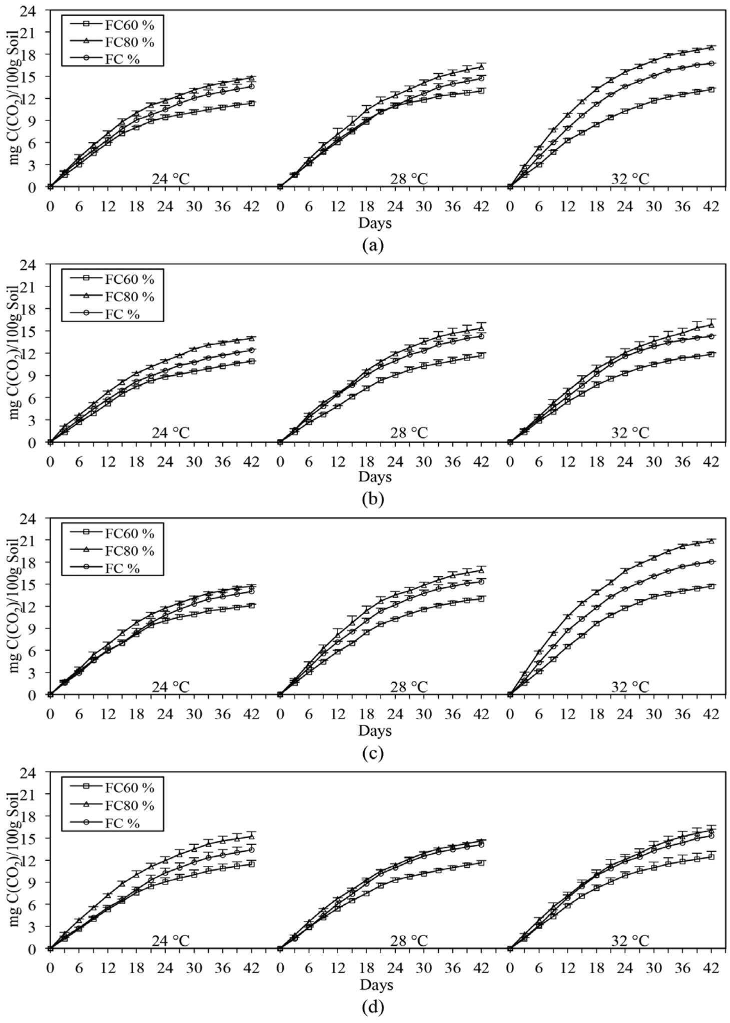

FIGURE 1. Cumulative carbon mineralized at different temperatures (24, 28 and 32°C) and different moistures (FC60, FC80 and FC%) (a) 0-5 cm and (b) 5-15 cm of *Onobrychis beata* soils, (c) 0-5 cm and (d) 5-15 cm of *Trifolium speciosum* soils (mean ± SE, n =3) (42nd days)

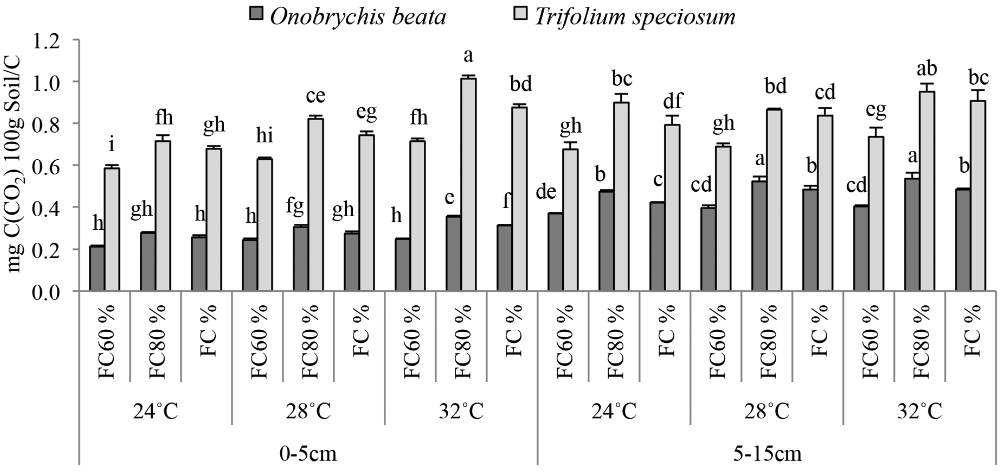

FIGURE 2. Rate of mineralization of organic carbon at different temperatures (24, 28 and 32°C) and different moistures (FC60, FC80 and FC%) and different depths (0-5 and 5-15 cm) of *Onobrychis beata* and *Trifolium speciosum* soils (mean ± SE, n=3)

TABLE 2. Effects of temperature, soil moisture and their interactions on C and N mineralization

	Soil depth		*Onobrychis beata*		*Trifolium speciosum*	
			F	*P*	F	*P*
C mineralization	0-5 cm	T	50.009	0.000	122.078	0.000
		SM	94.166	0.000	117.554	0.000
		T × SM	3.594	0.025	6.836	0.002
	5-15 cm	T	10.744	0.001	3.668	0.046
		SM	49.947	0.000	23.721	0.000
		T × SM	0.539	0.709	0.377	0.822
N mineralization	0-5 cm	T	160.80	0.000	145.05	0.000
		SM	434.98	0.000	123.02	0.000
		T × SM	23.10	0.000	49.56	0.000
	5-15 cm	T	20.70	0.000	53.99	0.000
		SM	44.34	0.000	27.97	0.000
		T × SM	16.09	0.000	0.85	0.511

T: Temperature, SM: Soil moisture

TABLE 3. Parameters estimated according to the first-order exponential model for soil carbon mineralization

			C_m	C_0	k	C_0k	r^2
			(mg CO_2-C $100g^{-1}$)		($days^{-1}$)	(mg CO_2-C $100g^{-1}$ d^{-1})	
Onobrychis (0-5 cm)	24°C	FC60	11.31	12.79	0.053	0.67	0.996
		FC80	14.80	17.51	0.046	0.80	0.999
		FC	13.60	16.63	0.042	0.69	0.999
	28°C	FC60	13.00	16.07	0.043	0.69	0.991
		FC80	16.25	21.57	0.035	0.75	0.998
		FC	14.68	20.28	0.032	0.65	0.998
	32°C	FC60	13.19	16.77	0.038	0.64	0.998
		FC80	18.91	21.81	0.050	1.10	0.999
		FC	16.75	20.89	0.041	0.87	0.996
Onobrychis (5-15 cm)	24°C	FC60	10.89	12.95	0.045	0.58	0.994
		FC80	13.96	17.01	0.043	0.73	0.999
		FC	12.40	15.27	0.041	0.62	0.998
	28°C	FC60	11.61	15.74	0.034	0.53	0.995
		FC80	15.34	20.67	0.034	0.71	0.997
		FC	14.26	18.70	0.036	0.67	0.998
	32°C	FC60	11.85	15.18	0.038	0.58	0.997
		FC80	15.76	20.95	0.034	0.72	0.998
		FC	14.26	19.22	0.035	0.68	0.992
Trifolium (0-5 cm)	24°C	FC60	12.07	14.32	0.047	0.67	0.996
		FC80	14.72	18.56	0.040	0.74	0.997
		FC	14.00	19.84	0.031	0.61	0.996
	28°C	FC60	12.97	16.93	0.037	0.63	0.996
		FC80	16.90	20.49	0.043	0.88	0.997
		FC	15.33	19.46	0.040	0.77	0.997
	32°C	FC60	14.72	19.51	0.036	0.70	0.993
		FC80	20.88	24.67	0.046	1.14	0.999
		FC	18.04	22.61	0.040	0.91	0.997
Trifolium (5-15 cm)	24°C	FC60	11.40	14.29	0.040	0.57	0.996
		FC80	15.21	18.75	0.042	0.78	0.999
		FC	13.40	19.34	0.030	0.57	0.996
	28°C	FC60	11.65	14.36	0.041	0.59	0.998
		FC80	14.60	18.52	0.039	0.72	0.999
		FC	14.12	19.69	0.032	0.64	0.994
	32°C	FC60	12.43	15.53	0.040	0.63	0.997
		FC80	16.05	20.92	0.036	0.75	0.999
		FC	15.33	20.09	0.036	0.71	0.995

C_m: quantity of C mineralized through incubation period, C_0: quantity of soil potentially mineralizable C, k: mineralization rate constant, C_0k: potential rate of initial C mineralization (mean value ± SE; *n*=3)

TABLE 4. Nitrogen mineralization (mg kg^{-1}) of *Onobrychis beata* and *Trifolium speciosum* (before and after carbon mineralization, 42 days)

			Onobrychis beata			*Trifolium speciosum*		
			NH_4-N	NO_3-N	N min rate	NH_4-N	NO_3-N	N min rate
Before C Mineralization (0-5 cm)			10.30 ± 0.02 fh	0.47 ± 0.07 e	0.33 ± 0.00 ij	6.35 ± 0.17 ij	0.44 ± 0.07 hi	0.37 ± 0.01 l
		60 % FC	11.00 ± 0.06 ef	0.52 ± 0.06 e	0.35 ± 0.00 gj	6.91 ± 0.06 hi	0.54 ± 0.04 gi	0.41 ± 0.00 kl
	24°C	80 % FC	13.66 ± 0.41 d	0.74 ± 0.04 de	0.44 ± 0.01 ef	7.77 ± 0.10 fh	0.63 ± 0.03 fh	0.47 ± 0.00 jk
		100 % FC	16.45 ± 0.47 c	1.04 ± 0.04 ce	0.53 ± 0.02 cd	8.00 ± 0.13 dh	0.71 ± 0.01 eg	0.49 ± 0.01 jk
		60 % FC	12.55 ± 0.43 de	0.98 ± 0.03 ce	0.41 ± 0.01 eg	8.01 ± 0.07 dg	0.72 ± 0.03 dg	0.49 ± 0.00 jk
0-5 cm	28°C	80 % FC	15.90 ± 0.26 c	1.88 ± 0.94 bd	0.56 ± 0.01 cd	9.67 ± 0.12 bc	1.09 ± 0.07 b	0.60 ± 0.01 gi
		100 % FC	20.43 ± 0.62 a	4.36 ± 0.24 a	0.75 ± 0.02 a	5.73 ± 0.13 j	1.83 ± 0.09 a	0.42 ± 0.01 kl
		60 % FC	13.75 ± 0.41 d	0.84 ± 0.03 ce	0.44 ± 0.01 e	9.02 ± 0.07 bd	0.64 ± 0.03 fh	0.54 ± 0.00 hj
	32°C	80 % FC	17.04 ± 0.10 c	2.02 ± 0.09 bc	0.58 ± 0.00 bc	9.83 ± 0.04 ac	1.06 ± 0.05 bc	0.61 ± 0.00 fh
		100 % FC	18.71 ± 0.13 b	2.36 ± 0.17 b	0.64 ± 0.00 b	8.19 ± 0.17 df	1.13 ± 0.06 b	0.52 ± 0.01 ij
Before C Mineralization (5-15 cm)			7.34 ± 0.62 k	0.90 ± 0.05 ce	0.32 ± 0.03 j	7.89 ± 0.26 eh	0.34 ± 0.07 i	0.59 ± 0.01 hi
		60 % FC	7.92 ± 0.14 jk	0.87 ± 0.02 ce	0.34 ± 0.01 ij	8.05 ± 0.32 dg	0.46 ± 0.04 hi	0.61 ± 0.02 eh
	24°C	80 % FC	8.07 ± 0.12 ik	0.90 ± 0.01 ce	0.34 ± 0.00 hj	8.79 ± 0.05 cf	0.55 ± 0.04 gi	0.67 ± 0.01 dg
		100 % FC	9.10 ± 0.12 gj	0.86 ± 0.03 ce	0.38 ± 0.00 ei	7.06 ± 0.05 gi	0.55 ± 0.03 gi	0.54 ± 0.01 hj
		60 % FC	9.00 ± 0.11 gj	0.89 ± 0.02 ce	0.32 ± 0.03 j	9.06 ± 0.44 bd	0.56 ± 0.04 gi	0.69 ± 0.04 ce
5-15 cm	28°C	80 % FC	8.18 ± 0.04 ik	1.71 ± 0.14 be	0.38 ± 0.01 fj	9.77 ± 0.24 bc	0.96 ± 0.04 bd	0.77 ± 0.01 ab
		100 % FC	10.57 ± 0.06 fg	2.64 ± 0.33 b	0.51 ± 0.01 d	8.48 ± 0.52 df	1.03 ± 0.04 bc	0.68 ± 0.04 cf
		60 % FC	9.65 ± 0.17 fi	0.77 ± 0.03 ce	0.40 ± 0.01 eh	10.07 ± 0.04 ab	0.53 ± 0.03 gi	0.76 ± 0.00 bc
	32°C	80 % FC	8.75 ± 0.05 hk	1.67 ± 0.06 be	0.40 ± 0.00 eh	10.91 ± 0.07 a	0.84 ± 0.03 cf	0.84 ± 0.01 a
		100 % FC	9.41 ± 0.40 fj	1.54 ± 0.07 be	0.42 ± 0.02 ef	8.96 ± 0.04 ce	0.90 ± 0.01 be	0.70 ± 0.00 bd

Different letters in the same column indicate significant differences (p<0.05). FC: Field capacity, SOC: Soil organic carbon, TN: Total nitrogen C/N: Ratio of C/N (mean value ± SE; n=3) (*p*=0.511) but no interaction found in 5-15 cm of both soils (*p*>0.05) (Table 2).

DISCUSSION

Effect of drying and rewetting on soil carbon mineralization and soil microbial activity were researched by many scientists and they reported that there were increase and stimulation in rates of mineralization (Birch 1958; Bloem et al. 1992; Zengin et al. 2008). This effect is called 'Birch Effect' and this rise originate from increase in the availability of decomposable substrates which is used by soil microorganisms as an energy source for their vital activity after drying and rewetting (Sorensen 1974). These substrates become available for soil microbial and fungal community that is mineralized and released rapidly to CO_2 through atmosphere (Jager & Bruins 1975). This study showed that soil temperature and moisture are driving factors in carbon and nitrogen mineralization as many authors reported.

It is known that labile fractions of soil organic matter (SOM) are important to study in as these fractions supply food web in the soil and influences nutrient cycles and many chemical and biological soil properties (Weil et al. 2003). Most researchers claimed that effects of either temperature or water on SOM decomposition but combined effects of both were reported by only a few (Howard & Howard 1993; Yuste et al. 2007). In general, cumulative carbon mineralization was lowest at FC 60% and 24°C in all soils and C_m of *Trifolium* soil were nearly same with *Onobrychis* soil that their differences between them may come from SOM difference in each soil. Also C_m was lower at 5-15 cm depth than at 0-5 cm depth of both soils as expected. It is possible to say that most of the SOM is used by microorganisms as energy source and faster mineralization were observed at 0-5 cm depth than 5-15 cm. Because SOM was more labile in upper horizon than deeper horizon. The results of Rey et al. (2005) strongly correlated with our results and they reported that most of the labile fractions gets into the top layer and is rapidly mineralized, whereas there were more recalcitrant fractions in deeper soils over time. The same author indicated that rates of carbon mineralization are more sensitive to alterations in water content at the high temperatures that are generally observed during the spring and summer in Mediterranean climate. On the other hand, Guntinas et al. (2013) claimed that sensitivity of the SOM to temperature was higher at low soil moisture contents and also suggested that any prediction model of CO_2 efflux from soils should take account of the effects of temperature, moisture and their combined effects. We found that combined effects of same parameters had a significant interaction on carbon mineralization in all soils except 5-15 cm depth of *Trifolium* soil.

In general, potential mineralizable C (C_0) was increased all soils as rising soil temperatures. The best field capacity was FC 80% and 32°C was the best temperature for C_0 that was lower at 5-15 cm than at 0-5 cm of both soils. k was variable in all treatments but generally, differences were clear between 0-5 cm and 5-15 cm depth of *Onobrychis* soils in k levels but they were similar which may be come from similarity of SOM in both depths of *Trifolium* soil. Qi et al. (2011) reported that soil moisture content controlled C_0 as it rose of elevation and soil moisture effects on carbon mineralization and suggested that soil water content altered microbial activity and finally affected $C_{0.}$

Effects of five soil temperature and five water holding capacity (WHC) on soil N mineralization using grassland soils in Inner Mongolia for 71 days of incubation were investigated by Li et al. (2014) and reported that the mineral N production and rates of N mineralization were positively correlated with temperature and active soil N mineralization occurred in 60%-80% WHC conditions. Guntinas et al. (2012) reported that 25°C was the maximum for sensitivity to temperature and the best WHC content for N mineralization of different soils (Forest, cropland and grassland) was between 80% and 100% of field capacity. The results of N mineralization were found similar as the other authors reported in their articles and more variable than C mineralization in this study. Soil moistures and temperatures generally increased ammonium, nitrate and rate of mineralization at 42nd day than 1st in all depths of soils and highest ammonium and nitrate contents were found at 100% FC in all temperatures at 0-5 cm depth of *Onobrychis* soil of this study. However, ammonium and nitrate contents were generally lower at 5-15 cm depth of *Onobrychis* soil than its upper layer. In contrast, while ammonium contents were higher, nitrate levels were lower in deeper soils of *Trifolium* than upper layer while in both depths in all temperatures and field capacities. On the other hand, best temperature and moisture for N mineralization rate were 28°C and 100% FC in both depths of *Onobrychis* while it was 32°C and 80% FC for both depths of *Trifolium* soil at 42nd day.

The main result of this study showed that highest CO_2-C evolution was obtained at 32°C and FC 80% in all depths of both soils and also decomposition of soil organic matter through C mineralization under the effects of increasing in temperatures were more stable than in N mineralization. C and N mineralizations were significantly affected by the interactive effects of temperature and moisture in top soils. N mineralization were increased in all soils compared their controls as expected but when results of NH_4-N, NO_3-N and rate of N mineralization under these parameters were compared, these were variable and decomposition of SOM were not stable like in the pathway of C mineralization. Soil depth is the main factor in N mineralization by affecting soil temperature and moisture while soil temperature was main driving factor and more important than soil moisture in soil C mineralization for this study.

CONCLUSION

Plant species, soil depth, temperature and moisture affected both C and N mineralization in the soils studied. Sensitivity to temperature in cumulative C mineralization was observed at 32°C in upper layer while it was 24°C in deeper layer of both soils and potentially mineralizable C, were risen as temperature increased. Further researches should be conducted to determine C and N mineralizations in different plants for long term and broad range of temperature and soil moisture can be applied in appropriate for global climate warming. We hope that this study results will help preventing negative effects of climate change in soil in future of East Mediterranean Region.

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