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TEMPERATURE INFLUENCE ON N MINERALISATION POTENTIAL IN DIFFERENT LAND USES IN ARTVIN, TURKEY

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Abstract. In this study, effects of different temperatures (10, 15 and 20°C) on N mineralisation potential were investigated in young spruce stands, old spruce stands with and without *Rhododendron ponticum* understory, and adjacent grasslands in the Genya mountain, Artvin, Turkey. Soil samples were taken from surface 0–15 cm soil depth and incubated in standard laboratory conditions (60% water holding capacity (WHC)) to determine mineralisation potential for 63 days period. Soil N mineralisation rates differed with temperature and vegetation type. Mineralisation potential at 10°C temperature was greater in spruce stands with *Rh. ponticum* understory (108.90 kg N/ha/63 days) than in the other sites. On the other hand, mineralisation potentials at 15 and 20°C were the greatest in grassland (103.51 kg N ha/63 days and 94.12 kg N ha/63 days) sites compared to other sites. There were positive correlation between N mineralisation potential and soil total nitrogen content (% and kg/ha) and negative correlation between N mineralisation potential and C/N rate.

Keywords: nitrogen mineralisation, the Artvin Genya mountain, nitrifications.

AIMS AND BACKGROUND

Nitrogen generally is the most limiting nutrient for plants in terrestrial ecosystems[1]. Its concentrations in soil can alter the diversity and composition of the plant communities[2]. On the other hand, the composition and diversity of plants have controlling effects on rate of nitrogen cycling, affecting inorganic nitrogen levels in soil[3,4]. Reciprocal effects between N availability and plant community structure result in positive feedback, leading to the persistence of certain plant communities in different areas[5,6].

Both mineralisation in soil and availability of nitrogen are important indicators of productivity and dynamism of ecosystems[7,8]. Uptake of inorganic nitrogen by plants and soil microorganisms is crucial for the maintenance of fertility and production in terrestrial ecosystems[9,10]. Therefore, net N mineralisation is usually considered as a key process in these ecosystems[11–14].

There are limited number of N mineralistaion studies in Blacksea region of the Turkey[15].

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The objectives of this study were to compare rates of N mineralisation among young oriental spruce stands (SSYs), old oriental spruce stands with no understory (SSOs), old oriental spruce stands with a *Rhododendron ponticum* L. understory (SSRs) and in adjacent grasslands, and to identify the underlying environmental variables most likely causing differences in N mineralisation among sites, and among seasons within sites. We hypothesised that grasslands have higher rates of soil N mineralisation rates than do adjacent spruce stands.

EXPERIMENTAL

The study site is located at the Genya mountain in Artvin, Turkey. The site with a northern aspect and gentle slope (10–20%), ranges in elevation from 1490 to 1510 m. Soil at the site is a podsolic well-drained sandy-loam anonym 2005). Soil mineralisation was studied in SSYs, in SSOs, in SSRs and in adjacent grasslands. Young stands were around 20-year old and were established after clear-cutting by planting and natural regeneration. Old stands were around 95-year old with normal canopy cover. Plot sizes were 20 × 20 m. Dominant grass species in the grassland sites were smooth brome (*Bromus inermis* L e y s s e r.), *Agrostis tenuis* L., timothy (*Phleum pratense* L.), Kentucky bluegrass (*Poa pratensis* L.) and *Festuca* spp. Grassland sites were under heavy grazing until last 5 years when grazing was stopped.

Our soil samples were taken from surface 0–15 cm depth with a cylindrical cubes container of 15×15×15 cm. Soil samples were taken in 2012. Soil samples were sifted through with a standard 2-mm stainless steel sieve and then dried in air. The soil core was separated from their stone and plant parts with a standard 4-mm sieve and put into nylon bags with label, and then weighed.

Soil moisture (%) was determined according to gravimetrical method. The maximum water holding capacity was determined as the difference between dried and wetted weights of soil samples.

Soil pH was determined by a combination glass electrode in H_2O (soil-solution ratio 1:2.5) and were measured with inolab pH level I pH (Ref. 16). Organic matter contents of the soils were determined according to the wet digestion method described by Kalra and Maynard[17] (the modified Walkley–Black method)[16]. Micro-distillation method was used in the determination of mineral nitrogen[18–20]. The Kjeldhal wet digestion method was used for the determination of total nitrogen[20].

Standard incubatıon and mineral nitrogen production. 100 g of air-dried soil were put into two polyethylene bags and humidified with distilled water to reach 60% Water-holding Capacity (WHC). Samples were then placed into an incubator set at 10, 15 and 20^{o}C for 9 weeks (63 days). The mineral nitrogen analyses were made in the 63rd day of incubation. The mineral nitrogen analyses by the micro-distillation method[18,19].

Calculation of nitrogen mineralisation rates. Mineral nitrogen was analysed 63 days of incubation. Net mineral nitrogen accumulations were calculated between 63nd days and 0st days. Differences were used to calculate the net mineral nitrogen production for each period. Net mineral nitrogen production was then expressed as nitrogen mineralisation rates[18,19].

The differences among the samples regarding to the mineral nitrogen values and the net mineralisation were tested by analyses of variance. The significance among means was determined using the Tukey test. Also, correlation between net mineral nitrogen productivity and some soil proporties (pH, WHC, C%, N%and C/N%) were tested using correlation and regression analyses. All of the statistical tests were performed at the significance level of a= 0.05, with Statistica Version 6.0 (Stat Soft Inc. 1984–1995) and SPSS 16.0 packet program.

RESULTS AND DISCUSSION

Soil pH, water-holding capacity, organic C, total nitrogen and C/N values of the study sites are given in Table 1. Soil pH, total N and organic C values of vegetation types were significantly different from each other (P<0.05). The lowest soil pH were measured in spruce stands with and without rhododendron understory (4.72±0.12) while the highest soil pH were in young spruce stands (5.07±0.14) (Table 1). According to Tukey test results, soil pH values in young spruce stands were significantly different than in the others.

Table 1. Average values of some soil properties in soil of 4 plant communities and significance level for differences among communities (mean ± standard deviations; P<0.05 significantly differences)

Parameter	SSYs	SSOs	SSRs	Grasslands
pH	5.07^{a}±0.14	4.72^{b}±0.32	4.72^{b}±0.12	4.76^{b}±0.11
WHC (%)	96.50^{a}±11.10	105.22^{a}±14.2	103.20^{a}±8.20	104.32^{a}±7.18
Total N (%)	0.30^{a}±0.08	0.37^{a}±0.09	0.38^{a}±0.09	0.41^{a}±0.07
Total N (kg/ha)	1632^{b}±400	1850^{b}±411	2105^{b}±372	3288^{a}±450
Organic C (%)	6.92^{a}±1.12	7.22^{a}±0.72	7.92^{a}±0.65	7.01^{a}±0.62
Organic C (kg/ha)	37880^{b}±6212	38900^{b}±5012	40010^{b}±4279	55018^{a}±3900
C/N	23.21^{a}	21.02^{a}	19.01^{a}	16.73^{a}

The greatest soil water holding capacity was measured in grassland sites (104.32±6.11) while the lowest was in young spruce stands (96.50±11.10). Soil N content varied significantly among sites. Grasslands sites had the greatest soil N content (3288±450 kg/ha) compared to the other sites (Table 1).

Soil organic C values (kg/ha) differed significantly among vegetation types (P>0.05). The greatest soil organic C were measured in grassland sites

(55018.3±3900 kg/ha). According to Tukey test, grassland organic C values differed significantly from the other sites (Table 1).

The lowest C/N ratios were measured in grassland sites (16.73) (Table 1). However, there was no significant difference among vegetation types. C/N ratio is considered as a good indicator of the net N mineralisation potential[21]. It was reported that there had been a negative correlation between N mineralisation and C/N ratio[21,22]. This was true in this study, too. We observed the greatest N mineralisation in the sites with the lowest C/N ratios (grassland sites).

Guleryuz[23] found strong negative correlation between net ammonium mineralisation and pH in alpine grassland. However, in this study we found relatively low positive correlation ($r = 0.019$). This might be due to higher soil organic matter contents of our sites (Table 5).

Table 2. NH_4^+–N mineralisation after 63 days of incubation period at different temperatures

Communities	10°C	15°C	20°C
SSYs	57.38^{b}±10.78	53.51^{ab}±12.54	41.59^{b}±10.21
SSOs	48.94^{b}±1.08	37.51^{b}±9.21	33.17^{b}±9.85
Grasslands	81.60^{a}±12.30	75.12^{a}±9.65	63.21^{a}±10.03
SSRs	96.19^{a}±16.06	77.85^{a}±8.42	73.24^{a}±11.80

Table 3. Mineralisation after 63 days of incubation period at different temperatures

Communities	10°C	15°C	20°C
SSYs	12.76^{a}±8.29	21.56^{a}±8.20	31.12^{a}±10.21
SSOs	14.87^{a}±9.21	29.12^{a}±6.32	40.03^{a}±11.12
Grasslands	15.78^{a}±8.25	28.38^{a}±7.21	27.25^{a}±8.24
SSRs	12.87^{a}±7.25	21.31^{a}±5.32	20.87^{a}±6.23

Table 4. Total mineral nitrogen (NH_4^+–N + NO_3^-–N) after 63 days of incubation period at different temperatures

Communities	10°C	15°C	20°C
SSYs	70.14^{b}±9.18	75.26^{ab}±10.25	72.71^{a}±10.12
SSOs	63.81^{b}±9.21	66.63^{b}±8.31	73.21^{a}±10.22
Grasslands	97.38^{a}±10.18	103.51^{a}±8.17	90.46^{a}±9.72
SSRs	108.90^{a}±15.21	99.17^{ab}±7.18	94.12^{a}±9.12

Table 5. Correlations between NH_4^+–N_{min} mineralisation rates (kg/ha) and soil properties at three temperature (10, 15, 20°C)

Parameter	T (°C)	*r*	*p*	*Y=a+bx*
NH_4–N				
pH	10	0.019	0.31	4.77+0.002 pH
	15	0.07	0.68	4.82–0.001 pH
	20	–0.15	0.35	4.86–0.001 pH
WHC	10	0.30	0.07	93.129+0.12 MSK
	15	0.07	0.67	100.45+0.02 MSK
	20	0.11	0.51	99.78+0.41 MSK
Organic C (%)	10	0.10	0.53	6.83+0.003 %C
	15	–0.11	0.51	7.25–0.02 %C
	20	–0.03	0.82	7.13–0.001 %C
Organic C (kg/ha)	10	0.29	0.08	35823.63+100.01 C(kg/ha)
	15	0.10	0.42	37697.25+85.67 C(kg/ha)
	20	0.29	0.07	37920.82+94.82
Total N (%)	10	0.46	0.04	0.24–0.002 total N (%)
	15	0.45	0.04	0.35+0.001 total N (%)
	20	0.42	0.08	0.33+0.001 total N (%)
Total N (kg/ha)	10	0.51	0.01	1132.75+15.23 total N (kg/ha)
	15	0.52	0.03	1840.35+6.13 total N (kg/ha)
	20	0.57	0.04	1726+9.25 total N (kg/ha)
C/N	10	–0.47	0.003	25.09–0.07* C/N
	15	–0.12	0.47	20.84–0.15* C/N
	20	–0.14	0.41	20.93–0.02* C/N

In this study, the correlations between nitrogen mineralisation with total nitrogen and organic matter (kg/ha) were slightly high. Guleryuz[23,24] found high correlations in their studies too. Slightly high correlations in our study might be due to the low pH values in our sites (Table 6).

Our NH_4–N and NO_3–N mineralisation rates were lower than the rates reported by the others. Guleryuz et al.[25] reported that NH_4-N mineralisation was 46.6 kg/ha and NO_3–N was 152.7 kg/ha in *Plantago holosteum* S c o p. plant community after 63 days of incubation period in surface 0–15 cm of soil. The lowest rates observed in this study could be the result of the relatively lower pH rates in our sites. Curtin et al.[26] reported that N mineralisation increased in acidic soil with the increasing soil pH.

Unver et al.[15] found greater N mineralisation rates in soils incubated at 25°C with a 63-day incubation period in the same sites than the values obtained in this study.

The greatest N mineralisation in grassland sites were measured in soils incubated at 15°C (104.32 kg/ha). On the other hand, spruce stands with rohododendron understory showed the greatest N mineralisation in soils incubated at 10°C (108.90 kg/ha). This indicates that each sites might have microorganisms that adapted to different temperatures.

Table 6. Correlations between NO_3^-–N_{min} mineralisation rates (kg/ha) and soil properties under three temperature (10, 15, 20°C)

Parameter	T (°C)	*r*	*p*	*Y=a+bx*
NO_3–N				
pH	10	–0.03	0.83	4.79–0.001*pH
	15	0.08	0.55	4.72+0.02*pH
	20	0.18	0.27	4.69+0.02*pH
WHC	10	–0.30	0.07	107.39–0.39*MSK(%)
	15	–0.04	0.83	102.82–0.03*MSK(%)
	20	0.21	0.20	97.32+0.13*MSK(%)
Organic C (%)	10	–0.11	0.53	7.21–0.01* C(%)
	15	–0.03	0.87	7.12–0.001 C(%)
	20	0.01	0.49	6.89+0.05 C(%)
Organic C (kg/ha)	10	–0.06	0.72	39465.90+249.42* C(kg/ha)
	15	0.31	0.06	36864.27+7.87* C(kg/ha)
	20	–0.08	0.62	44278.57–45.30* C(kg/ha)
Total N (%)	10	0.50	0.02	0.37–0.001*total N(%)
	15	0.55	0.01	0.35+0.001*total N (%)
	20	0.58	0.01	0.34+0.001*total N (%)
Total N (kg/ha)	10	0.52	0.01	2060.01+11.15*total N (kg/ha)
	15	0.61	0.01	1833.00+1517*total N (kg/ha)
	20	0.59	0.01	2270.23–10.85*total N (kg/ha)
C/N	10	–0.08	0.67	20.40–0.04* C/N
	15	–0.06	0.71	20.44–0.02* C/N
	20	–0.15	0.37	20.38–0.04* C/N

Tufekcioglu and Kucuk[27] found lower rates of soil respiration in spruce stands compared to grassland sites in a study done in the same area. We also found higher N mineralisation rates in grassland sites. Higher microbial activity in grassland sites could be the one of the reasons behind the greatest N mineralisation rates observed in grassland sites.

CONCLUSIONS

Our results show that N mineralisation differs with vegetation types. Soil properties such as pH, organic C, total N, C/N and temperature influence soil N mineralisation.

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