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Denitrification Capacity of the Widely Distributed Soil Series of the Turkish Republic of Northern Cyprus

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A laboratory experiment was carried out to determine the denitrification capacity of the Doganci, Geçitkale, Akdeniz, Balikesir, Pamuklu, Zümrütköy and Türkmenköy that are widely distributed soil series of Turkish Republic of Northern Cyprus. Soils are placed in anaerobic jars (20 % initial O_2, 80 % He) with addition of 300 mg kg^{-1} NO_3^--N. Produced gases (CO_2, N_2 and N_2O) along with O_2 consumption were determined by gas chromatography. Moreover, ammonium and nitrate concentration of the soils were measured at regular intervals. The measured O_2 consumption and CO_2 production values as parameters of biological activities revealed considerable differences among the soil series studied. The more rapid O_2 consumption and the higher CO_2 production were determined in Balikesir, Zümrütköy and Türkmenköy soil series. Furthermore, O_2 level in the anaerobic jar was immediately dropped in early measurement intervals and was about 0 % at the end of the last measurement, particularly above mentioned soil series. The Zümrütköy soil series has higher CO_2 production in all measurement periods than the others and reached 975 μg CO_2 g dry $soil^{-1}$ at the end of experiment where others vary from 257 to 745. The measurements of N_2O and N_2 gases revealed that the most of the denitrification product consists of N_2. Additionally, the highest N_2O and N_2 productions were determined in the Balikesir series with 251 μg N_2O-N g dry $soil^{-1}$ and 498 μg N_2-N g dry $soil^{-1}$. When all series compared, there were significant differences for the production of N_2 and N_2O production. Nitrate and ammonium analyses measured in relation to time, ammonium content was similar in all series, however, nitrate content significantly decreased according to the measurement period.

Key Words: Denitrification, Nitrous oxides, Soil, Turkish Republic of Northern Cyprus.

INTRODUCTION

Efficient use of nitrogen fertilizer requires well understanding of nitrogen dynamics in the soil. Due to the many loss pathways, applied nitrogen fertilizer did not effectively used by plants. One of the major

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nitrogen losses progress, denitrification results economical and environmental impacts. The denitrification products, nitrous oxides, are effective as a "green house" and contribute to the formulation of tropospheric ozone[1,2]. Denitrification, therefore, occurs in many soil conditions, stimulated by nitrate and water contents of soil, temperature and insufficient oxygen diffusion[3,4]. The nitrogen fertilizers could easily convert to nitrate due to the nitrification progress and thus, denitrification would be triggered even in the case of utilization of ammonium as a nitrogen source. Fertilization with high levels of nitrogen (300 kg of N ha^{-1}) positively affected on the occurrence and amounts of the diazotrophic bacteria[5].

Low nitrogen use efficiency and high nitrate pollution potentials are the major problems in intensive agricultural production systems. Losses the denitrification in suitable condition accounted for *ca*. 25 % of the applied nitrogen[6,7]. Freney[7] reported that, the use of an inhibitor for limiting nitrification, prevents nitrogen loss by denitrification, increases grain nitrogen and resulted in a 46 % greater recovery of applied nitrogen in the plant-soil system at harvest.

The aim of the research was to determine the denitrification capacity of widely distributed Turkish Republic of Northern Cyprus (TRNC) soils.

EXPERIMENTAL

Some of physical and chemical properties of the sub soils (0-20 cm) of selected soil series were given in Table-1.

TABLE-1
SOME CHEMICAL AND PHYSICAL PROPERTIES OF THE SOILS

Soil series	Sand (%)	Clay (%)	Loam (%)	Texture class	$CaCO_3$ (%)	pH (1:1 H_2O)	Organic matter (%)	Salt (%)	N_{min} mg kg^{-1}
Doğanci	46.4	20.2	33.4	SCL	2.3	7.7	1.15	0.054	17.0
Geçitkale	27.2	43.0	29.8	CL	25.4	7.7	1.67	0.070	50.2
Akdeniz	76.3	11.7	12.1	SL	14.3	8.0	2.27	0.022	26.5
Balıkesir	26.6	39.3	34.1	CL	21.3	8.1	2.61	0.147	57.5
Pamuklu	41.2	24.0	34.8	CL	24.3	7.9	1.74	0.042	14.8
Zümrütköy	44.7	26.6	28.7	CL	5.8	8.0	2.43	0.096	64.5
Türkmenköy	33.6	30.0	36.4	CL	11.3	8.0	2.05	0.129	39.1

The selected soil samples were placed into anaerobic jars as soon as set to field capacity and enriched by 300 mg NO_3^--N kg^{-1} dry $soil^{-1}$. The atmosphere of the jar was adjusted for 20 % oxygen and 80 % helium (v/v). Samples incubated at 30ºC for 55 d. The atmosphere of the jar was analyzed by gas chromatography (Hewlett Packard GC 5890) equipped

with ECD (Electron Capture Detector) and TCD (Thermal Conductivity Detector). The gases of CO_2 and O_2 were measured using TCD (200ºC detector, 54ºC oven and 60ºC injector temperatures) whereas N_2 and N_2O were measured by ECD (300ºC detector, 54ºC oven and 60ºC injector temperatures)[8]. One parallel of the jars quashed on every other sampling day and the soils were analyzed for their nitrate[9] and ammonium[10] contents.

RESULTS AND DISCUSSION

Oxygen consumption and CO_2, N_2, N_2O fluxes

The effects of 55 d incubation on the gases of O_2, CO_2, N_2 and N_2O for the soil series of Doganci, Geçitkale, Akdeniz, Balikesir, Pamuklu, Zümrütköy, Türkmenköy were given in Figs. 1a and 1b.

Results revealed that, the initial 20 % oxygen was reduced in all soil series as a function of time. Therefore, in Balikesir, Zümrütköy and Türkmenköy, oxygen consumption was significantly higher ($P = 0.05$) than the other series. The measured oxygen percentage of Türkmenköy and Zümrütköy were decreased considerable in 13th measurement day and reached 0 % in Türkmenköy on 41st day whereas Zümrütköy on 48th. In the last measurement, oxygen percentage of the series of Doganci, Geçitkale, Akdeniz and Pamuklu were 7.5, 6.6, 5.8 and 6.2 %, respectively.

The CO_2 fluxes in Balikesir, Türkmenköy and Zümrütköy were significantly higher than the others, in accordance with O_2 consumption. Although, the measured CO_2 fluxes in Doganci, Geçitkale, Akdeniz and Pamuklu were increased rapidly; it was not significant ($p = 0.05$). The CO_2 values on the last measurement were 257, 445, 510, 745, 347, 974 and 676 μg CO_2/g dry soil for Doganci, Geçtikale, Akdeniz, Balikesir, Pamuklu, Zümrütköy and Türkmenköy soil series, respectively.

Results showed that the most of the denitrification products consisted N_2. The highest N_2 was measured in Balikesir series (498 μg N_2-N g ds^{-1}) where as the lowest was in 136 μg N_2-N g ds^{-1} in Turkmenköy.

The lowest N_2O-N values were 0.7 and 0.4 μg N_2-N g ds^{-1} in the Doganci and Türkmenköy, respectively while the highest value was in Balikesir (251 μg N_2-N g ds^{-1}).

The highest denitrification losses (N_2+N_2O) were determined in Balikesir (749 μg N g ds^{-1}) whereas the lowest were 137 μg N g ds^{-1} in Türkmenköy.

Nitrate and ammonium occurrence

One parallel of the jars was quashed every other sampling day and the soils were analyzed for nitrate and ammonium contents. The effects of 55 d incubation on the nitrate and ammonium contents of soils were given in Tables 2 and 3, respectively.

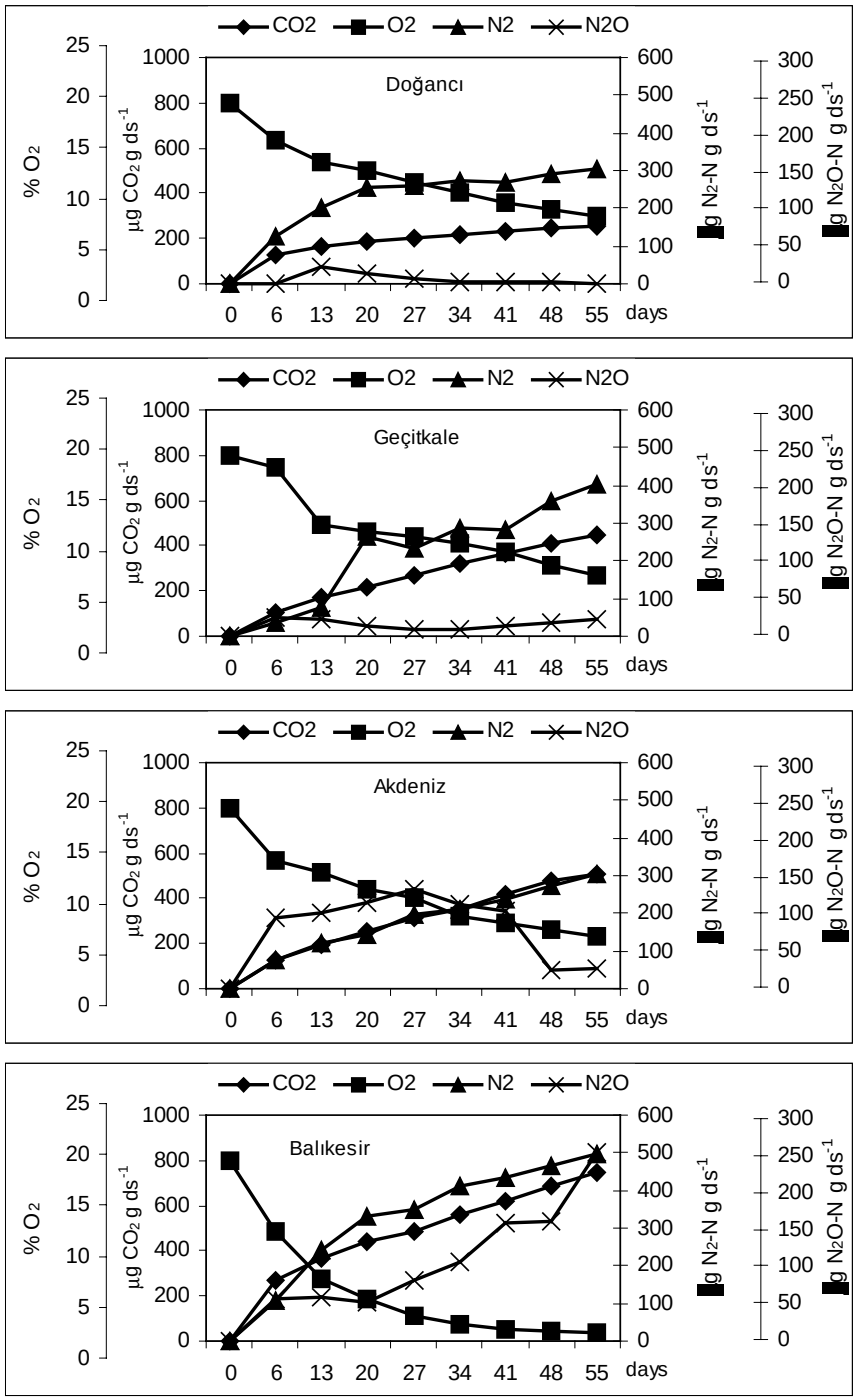

Fig. 1a. Fluxes of O_2, CO_2, N_2, N_2O for the Soil Series of Doganci, Geçitkale, Akdeniz, Balikesir Through 55 d Incubation

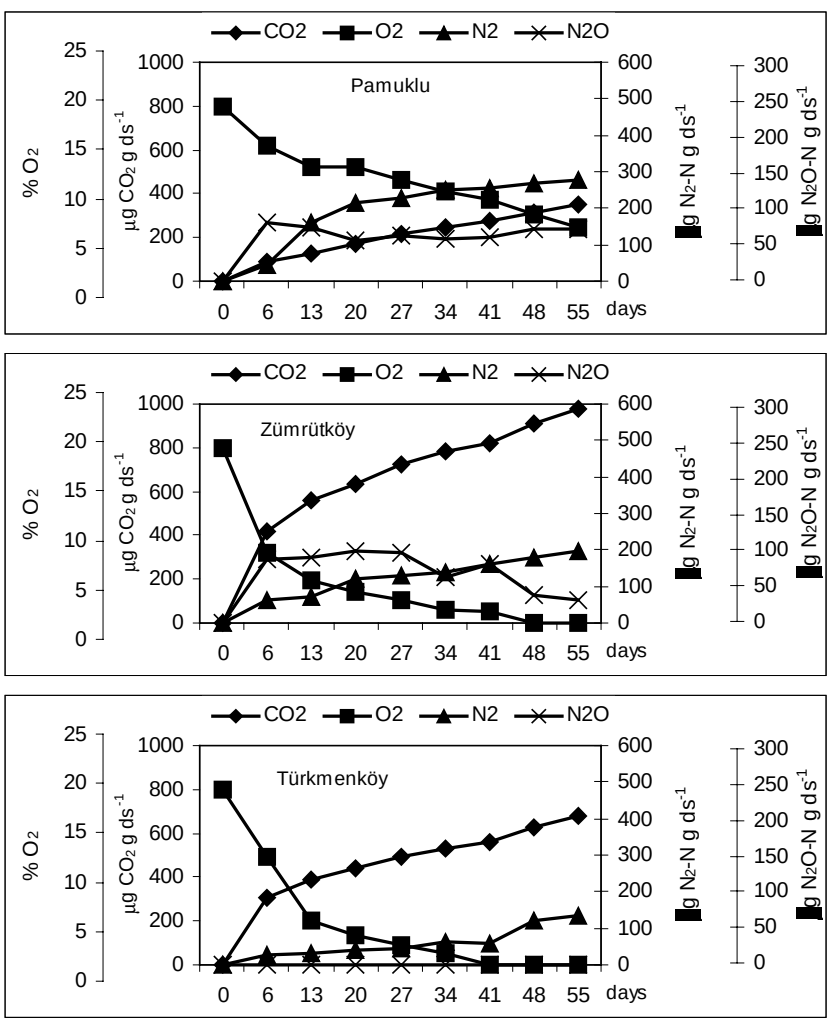

Fig. 1b. Fluxes of O_2, CO_2, N_2, N_2O for the Soil Series of Pamuklu, Zümrütköy, Türkmenköy Through 55 d Incubation

TABLE-2
EFFECTS OF INCUBATION ON NITRATE CONTENTS
(mg kg^{-1}) OF SOILS

	Days of measurement				
	0	13th	27th	41st	55th
Doğanci	310	289	286	220	281
Geçitkale	336	360	316	264	171
Akdeniz	314	244	212	183	126
Balıkesir	334	367	342	271	209
Pamuklu	307	294	255	228	226
Zümrütköy	309	330	305	210	172
Türkmenköy	319	316	299	258	226

TABLE-3
EFFECTS OF INCUBATION ON AMMONIUM CONTENTS
(mg kg^{-1}) OF SOILS

	Days of measurement				
	0	13th	27th	41st	55th
Doğanci	7	24	32	77	26
Geçitkale	14	19	16	29	21
Akdeniz	12	34	26	26	30
Balıkesir	24	22	19	44	25
Pamuklu	8	27	20	25	24
Zümrütköy	56	30	17	52	18
Türkmenköy	20	21	30	31	23

The soil nitrate contents were reduced as function of time in accordance with denitrification losses (N_2 and N_2O). In the Geçitkale, Akdeniz and Zümrütköy, the increments were significantly higher ($p = 0.05$). Ammonium contents showed relatively lower values than the nitrate contents due to the enrichment by nitrate-N in the beginning of experiment.

Conclusion

The incubation study for the determination of the denitrification potentials of the widely distributed soil series of the Turkish Republic of Northern Cyprus (TRNC) related that soils with similar mineral N contents prior the incubation, the N losses (N_2-N+N_2O-N) following NO_3^--N fertilization were significantly differing from each other. CO_2 production and O_2 consumption also showed significant flux differences related both to amount and time. Moreover, great amounts of denitrification losses occurred with the presence of molecular O_2. Significant differences both in denitrification and biological activity parameters should be most probably due to varying of soil properties, which also affected the biological properties as well. Abou-Seada & Ottow[11] suggested that denitrification losses are more closely related to waters soluble organic matter than the total organic matter content of the soil. Additionally, the presences of O_2 along with mineralizable organic matter content are also important factors for the denitrification losses[12]. Results revealed that the determinations of present and potential denitrification losses are very important factors for fertilizer consumption and environmental pollution (degradation of ozone layer).

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