Changes of nitrogen forms in a calcareous soil exposed to elevated CO_2 with two atmospheric temperature levels

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Abstract
Elevated carbon dioxide and other green house gases have increased the earth temperature in recent decades, thus may be affecting biochemistry cycles in soils. An experiment was conducted in a completely randomized design with factorial arrangement in the laboratory conditions. Soil was treated with one percentage of cow manure compost and 200 kg /ha of Urea. Soil samples were exposed to two levels temperatures (25 and 35) and two carbon dioxide concentrations (350 and 700 ppm) for a 60 day period of incubation with three replications. The results showed that elevated carbon dioxide at 25 and 35 ^oC had a different effect on total dissolved nitrogen. Elevated carbon dioxide at 25 ^oC had no significant effect on total dissolved nitrogen (TDN) while at 35 ^oC TDN was increased. Temperature and CO_2 had more effect on NO_3+NO_2 components of dissolved inorganic nitrogen than on NH_4. It seems that denitrification was higher in elevated CO_2 and high temperature treatments. Maximum and minimum rates of dissolved organic nitrogen (DON) occurred at 35 ^oC under elevated CO_2 faster than other treatments. This study revealed that elevated CO_2 and temperature enhanced nitrogen mineralization.

Key Words
Total dissolved nitrogen (TDN), total organic nitrogen (TON), nitrate, nitrite

Introduction
Fossil fuel combustion leading to elevated carbon dioxide and other green house gases may significantly increase earth temperature (Houghton *et al.* 1995). This may affect organic matter decomposition and mineralization of nutrients in soils. Phillips *et al.* (2002) showed an increase in organic matter degradation due to elevated atmospheric carbon dioxide. However in a three year experiment on a calcareous grassland soil Hungate *et al.* (1996) reported that carbon transformations in microbial biomass and organic carbon and nitrogen decomposition were not affected by increases in atmospheric CO_2. The authors further reported that soil nitrogen decomposition may vary due to increases in CO_2 among various ecosystems and even within a single ecosystem. Billings *et al.* (2002) investigated processes of the nitrogen cycle in desert soils exposed to elevated CO_2. They concluded that NH_4 volatilization is an important contributor to dissipated nitrogen gases in arid regions and low soil temperature limits microbial activity. The effect of elevated CO_2 on soil microbial activity was not similar in different seasons. It seems that temperature may be an important factor with respect to the CO_2 effect on nitrogen cycle in soil. The purpose of this work was to study the effect of temperature and CO_2 concentration on soluble forms of nitrogen in a calcareous soil in the north eastern of Iran.

Material and methods
An experiment was conducted in a completely randomized design with a factorial arrangement with two levels (25 and 35) temperatures and two carbon dioxide concentrations (350 and 700 ppm) during a 60 day period of incubation with three replications in the laboratory condition. Soil was initially treated with one percent of cattle manure compost and 200 kg/ha of urea. The pots contain 200 g of treated soil was transfer in CO_2 and temperature controlled chambers. In 0, 5, 10, 15, 30 and 60 days amounts of TDN, DIN, DON, sum of nitrate and nitrite and ammonium were measured in a 1:2.5 soil\water extract after 4 hour shaking time (Keeney and Nelson 1982; Cabrera and Beare 1993). Results were analyzed using MSTATC software and mean of treatment was compared using the Duncan test.

Results and discussion
The results showed that the highest and the lowest amount of total dissolved nitrogen (TDN) were for 35 ^oC at 350 and 750 ppm CO_2 concentrations. With increasing temperature, TDN decreased significantly at 350 ppm CO_2 concentration while temperature had different effect on TDN at 750 ppm CO2 concentration (Figure 1). It seems that nitrogen availability decreased when temperature increased from 25 ^oC to 35 ^oC at the low CO_2 concentration (350 ppm) due to increasing microbial activity. It is also possible to assume that

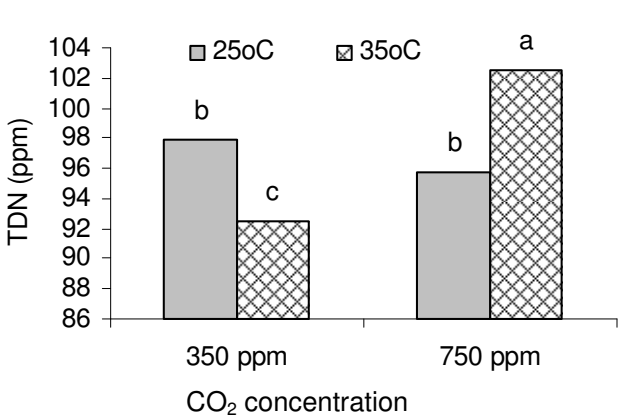

Figure 1. Effect of temperature and CO_2 concentration on total dissolved nitrogen (TDN).

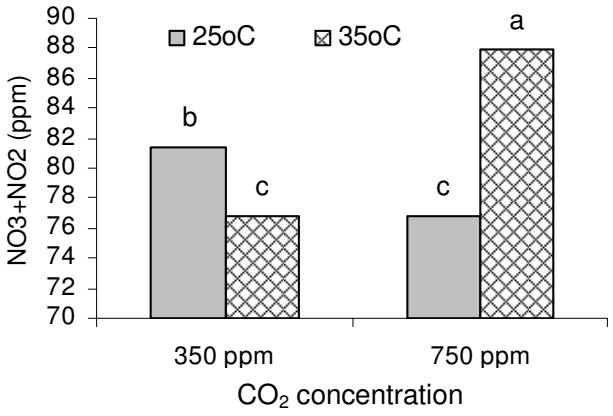

Figure 2. Effect of temperature and CO_2 concentration on $NO_3 + NO_2$ concentration.

the higher temperature and 750 ppm CO_2 concentration increased the activity of some microorganisms responsible for nitrogen mineralization.

Since DIN is a major part of TND any changes in TDN concentration seem to be related in DIN. For this reason the effect of temperature and CO_2 concentration on DIN components (NH_4, $NO_3 + NO_2$) was quite similar to the TDN pattern. Changes in $NO_3 + NO_2$ concentrations also were similar to TDN and DIN at different temperatures and CO_2 concentrations (Figure 2) because ammonium concentration constituted only about 5 percent of DIN. In addition temperature and CO_2 concentration did not have a pronounced effect on ammonium concentration. Therefore, the most changes observed in DIN or TDN seems to be due to changes in $NO_3 + NO_2$ concentrations. Carnol *et al.* (2002) showed that nitrate production increased under an elevated CO_2 condition. They hypothesized that physiological adaptation or selection of nitrificatores could occur under elevated CO_2. The effect of temperature and CO_2 on $NO_3 + NO_2$ concentration during sixty days of incubation is shown in Figure 3. The results revealed that $NO_3 + NO_2$ concentration increased with incubation time in all treatments. Ammonium concentration showed a different pattern and its concentration decreased dramatically during incubation. Cabrera and Beare (1993) reported that nitrogen mineralization increased under higher CO_2 concentrations in a paddy soil. However some studies reported a negative effect of CO_2 on nitrogen availability (Cotrufo *et al.* 1994).

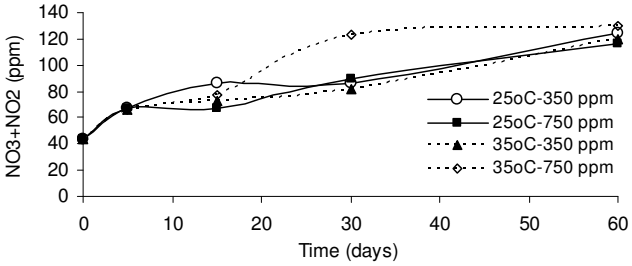

Figure 3. Effect of temperature and CO_2 on $NO_3 + NO_2$ concentration during two months of incubation.

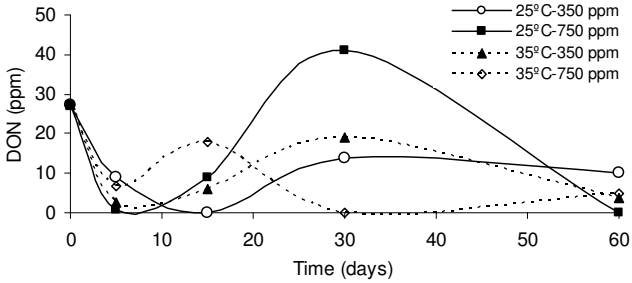

Figure 4. Effect of temperature and CO_2 on DON concentration during two months of incubation.

Our investigation showed that the maximum and minimum dissolved organic nitrogen occurred faster than for other nitrogen forms at 35 ^oC under elevated CO_2 (Figure 4). It may be concluded that elevated carbon dioxide with increasing temperature enhanced the rate of nitrogen biochemical reactions in soil.

Conclusion

The results revealed that the effect of elevated CO_2 on different forms of nitrogen was different at 25 and 35 ^oC. Elevated CO_2 had a non significant effect on TDN concentration at 25 ^oC while TDN was increased at 35 ^oC. TDN components were also affected by temperature and CO_2 concentrations. Changes in DIN were due to the changes in $NO_3 + NO_2$ concentration. In general, the results of this experiment demonstrated that temperature and elevated CO_2 may increase the nitrogen mineralization. However, in order to acquire a better perspective more research is needed.

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