NITRATE REDUCTASE ACTIVITIES OF AN ULTISOL: EFFECTS OF TILLAGE, CROPPING AND NITROGEN SOURCES.

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Abstract

Nitrate reductase catalyzes the initial and important step in denitrification. Denitrification represents a major source of N loss from agricultural soils and a major source of atmospheric N_2O. This study evaluated the effects of management practices on soil nitrate reductase activity (NRA). The treatments comprised of one or a combination of management practices that included three tillage methods, two sources of nitrogen, three levels of nitrogen, use or non use of cover crop (Secale cereale L.), and a bare fallow (control). The three tillage methods were conventional-till, no-till, and mulch-till. The two sources of nitrogen were poultry litter and ammonium nitrate. Soil NRA was significantly influenced by management practices. A significant increase in activity was observed with the addition of poultry manure. Results showed an increase in soil NRA were cover crop was planted. With respect to tillage practices, this study did not reveal significant difference in activity, although this was highest in no-tilled soils. Soil organic carbon (SOC), pH, microbial biomass nitrogen (MBN) showed a very strong correlation with NRA.

Introduction

- ✓ Increasing concerns about long term productivity of agro-ecosystems emphasize the need to develop management strategies that maintain and protect soil resources.
- ✓ Soil disturbance and residue placements lead to significant changes in soil biochemical properties resulting in significant changes in soil nutrient cycling.
- ✓ Enzyme activities in soil environments are a major contributor of overall soil microbial activity and to soil quality (Dick, 1994).These activities act as sensitive indicators of soil changes or status .
- ✓ Nitrate reductase is an important enzyme in denitrification and thus a significant enzyme in N-cycle enzyme.
- ✓ Extensive work has been done in assessing the effect of soil tillage and management practices on soil quality and nutrient cycling (Bandick and Dick, 1999; Deng and Tabatabai, 1997; Matocha et al., 2004). However, there is paucity of studies on the effect of management practices on soil nitrate reductase activities.

Objective

To evaluate the effects of management practices on soil nitrate reductase activities.

Materials and Methods

Samples

- ✓ The experimental design is a randomized complete block, with plot sizes of 8 m by 9 m, and The eight rows of crops.
- ✓ The treatments comprised of one or a combination of management practices Treatment consisted of one or a combination management practices that included: Bare fallow (BF); tillage practices [conventional till (CT), Mulch tillage (MT), and no-till (NT)]; cover crop [rye cover crop (R); inorganic fertilizer [0 Kg N ha^{-1} and 100 Kg N ha^{-1} (AN) from NH_4NO_3]; organic fertilizer [0 Kg N ha^{-1}, 100 kg N ha^{-1} (P) and 200 Kg N ha^{-1} (PP) from poultry manure].
- ✓ The soils physical and biochemical properties such included moisture, pH, nitrate (NO_3^-) microbial biomass nitrogen (MBN), Soil organic carbon (SOC), bulk density (BD), potential mineralizable nitrogen (PMN).

Materials and Methods continued

Nitrate Reductase Activity

- ✓ The substrate (KNO_3) concentration used was 20 m*M* (based on the K_{app} values).
- ✓ Air-dried soil samples (3 g), placed in 250 mL wide-mouth bottles were treated with 2 mL of appropriate amounts of DNP in ethanol. The ethanol was evaporated by use of a fan.
- ✓ The soil was then treated with 10 mL of substrate solution and the contents were incubated in the dark at 30 °C for 24 hrs.
- ✓ Nitrite formed was extracted by horizontally shaking the contents with 40 mL of 2 *M* KCl for 30 min. The soil suspension was then filtered using no. 42 Whatman filter paper.
- ✓ Nitrite in the resulting filtrate was determined using the Griess-Illosvay method.
- ✓ Statistical analysis of data involved the use of ANOVA, Pearson correlation and Tukey's multiple comparison procedure.

Results

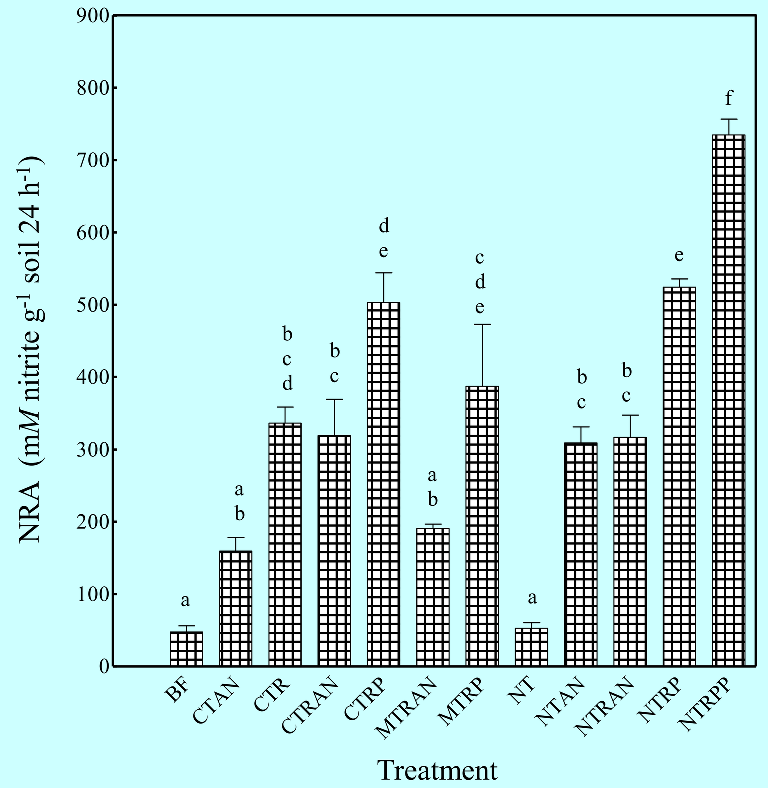

Fig.1. Soil nitrate reductase activity under different treatment.

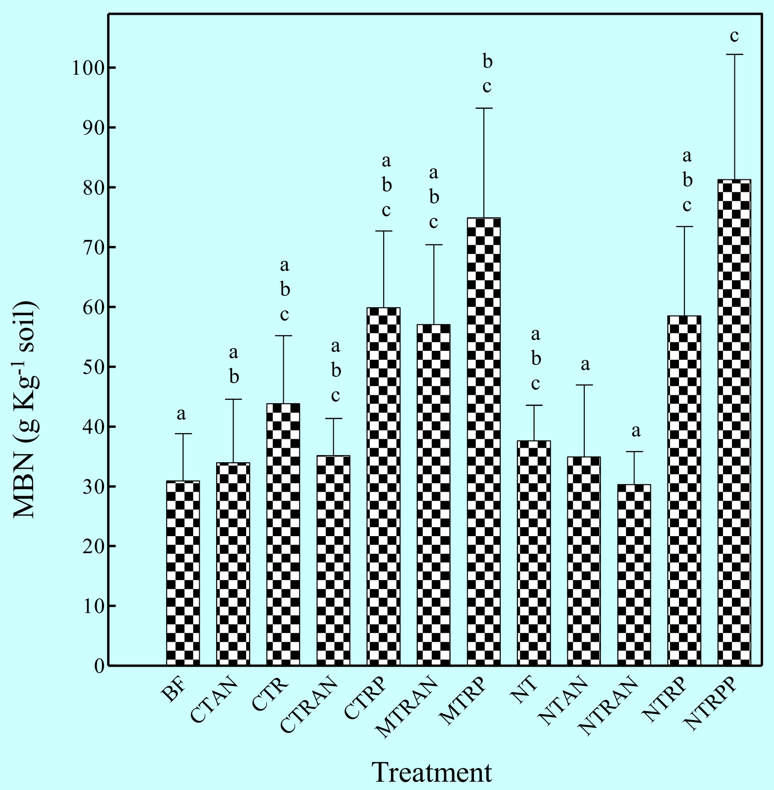

Fig. 2. Microbial biomass nitrogen under different treatment.

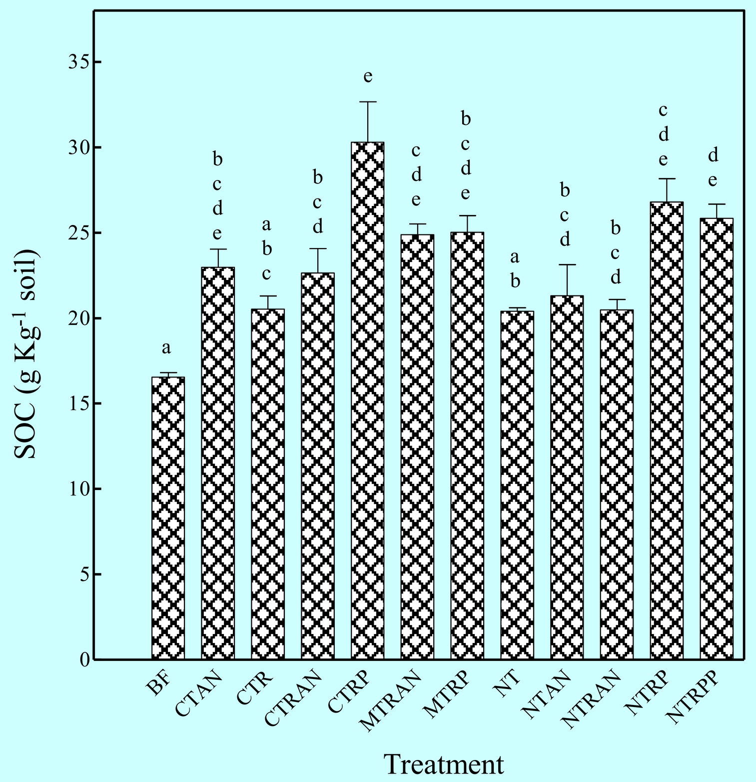

Fig. 3. Soil organic carbon under different treatment.

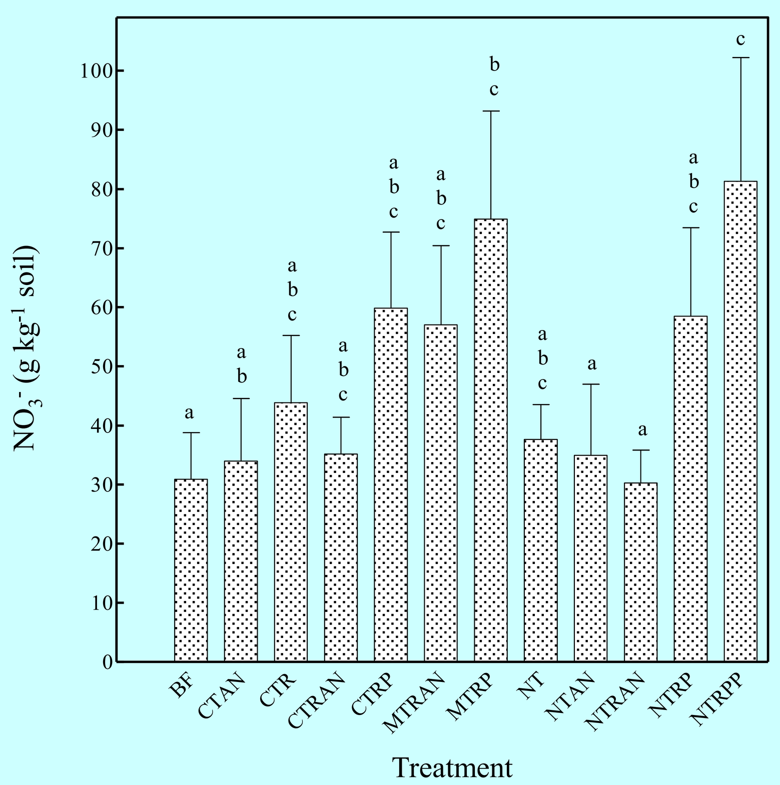

Fig. 4. Soil residual nitrate under different treatment.

The first two letters of the treatments are abbreviations for tillage practices, R is rye cover crop, and last letter(s) for fertilizer applied).

Results continued

Table 1. Correlation matrix between selected soil properties and nitrate reductase activity

	pH	MBN	NRA	NO_3^-	SOC	BD	PNM
				---------------- [b]R ----------------			
Moisture	0.260^ns	-0.011^ns	0.222^ns	0.369**	0.521***	0.147^ns	0.448**
pH		0.501***	0.498***	0.487***	0.585**	0.164^ns	0.479***
MBN			0.437**	0.576**	0.357*	0.087^ns	0.462**
NRA				0.484***	0.608***	0.056^ns	0.525***
NO_3^-					0.701***	0.128^ns	0.844***
SOC						0.106^ns	0.760***
BD							0.191^ns

[b] R = Correlation coefficient: *** , **, *, significant at $p< 0.001$, $p< 0.01$ level and $p< 0.05$ level (2-tailed) respectively; ns = not significant; N = 48
NRA [Nitrate reductase activity (μM nitrite released g^{-1} soil $24h^{-1}$)]; MBN = microbial biomass nitrogen, NO_3^- = nitrate; SOC = soil organic carbon; BD = bulk density ; PNM = potential nitrogen mineralization.

Discussion and Conclusion

- ✓ All treatments in this study (except for NT) showed significant increases in soil NRA compared to the control (BF). Soil NRA was significantly greater in NTRPP than all other treatments
- ✓ There was increase in soil NRA, with the addition of plant residue and poultry manure.
- ✓ No significant difference in NRA with respect to tillage practices, although activity was highest with NT soils.
- ✓ The soil residual nitrate values, pH, microbial biomass nitrogen (MBN) varied very significantly with treatment .
- ✓ The management practices exert their effects on nitrate reductase activity via soil physical and biochemical properties. NRA showed highly significant correlations with pH, SOC and MBN.
- ✓ The presence of crop residues and other decomposable organic matter may increases denitrification rates.
- ✓ High NRA may reflect a high population of denitrifiers, and thus a high potential for soil to lose N through denitrification. Nitrogen can be lost as N_2O, a green house gas that contributes to global warming. However, a high nitrate reductase activity may reduce the amount of nitrate that is leached to ground waters.

References

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