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*Full Length Article*

# Total Nitrogen Pedotransfer Function for Calcareous Soils of Varamin Region

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## ABSTRACT

In certain cases, it is important to determine empirical relationships among some soil physical and chemical properties. In soil science, such relationships are named pedotransfer functions. For instance, soil total nitrogen (TN) is often determined using cumbersome laboratory tests, but it may be more suitable and economical to develop a pedotransfer function, which uses easily available soil properties. In this study, a pedotransfer function for predicting soil TN from soil organic carbon (OC) was suggested and soil TN was estimated as a function of soil OC. The statistical results of the study indicated that in order to predict soil TN based on soil OC the pedotransfer function TN = 0.026 + 0.067 OC with $R^2$ = 0.83 can be recommended.

**Key Words:** Total nitrogen; Organic carbon; Pedotransfer function; Prediction; Soil; Varamin

## INTRODUCTION

Soil organic carbon (OC) and soil total nitrogen (TN) have long been identified as factors that are important to soil fertility in both managed and natural ecosystems (Kucharik *et al.*, 2001). It is well established that nitrogen (N) is the macronutrient often limiting the growth of plants on soil (Vitousek, 1982; Vitousek & Farrington, 1997; Michopoulos *et al.*, 2008). Moreover, soil organic matter and consequently soil OC are the most important attributes of a soil, because they affect nutrient cycling, soil structure and water availability. Maintaining, or better yet, increasing soil OC content is an important measure of the sustainability of a cropping system. In this direction, the USDA has developed a soil conditioning index that is a tool that can predict the consequence of cropping systems and tillage practices on the trend of soil OC accumulation (USDA-NRCS, 2002). A positive index is the first criterion used in the conservation security program (USDA-NRCS, 2004). Overall, management practices that contribute to increasing soil OC levels include those that add more OC to the soil than the amount removed from the system (e.g., crop residues), increase the diversity of OC added (e.g., manure), or decrease the rate of OC loss (e.g., reduced tillage) (Magdoff & Weil, 2004).

Numerous field studies have shown that crop management practices can either enhanced or diminish quantities of soil OC and soil TN together (Bauer & Black, 1981; Voroney *et al.*, 1981; Campbell & Souster, 1982; Odell *et al.*, 1984; Mann, 1986; Darmody & Peck, 1997; Paustian *et al.*, 1997; Buyanovsky & Wagner 1998; Dick *et al.*, 1998; Potter *et al.*, 1998; Knops & Tilman, 2000; Kucharik *et al.*, 2001). One hypothesized goal of sustainable agriculture is to increase soil OC and soil TN, or to maintain these quantities close to native levels (Odell *et al.*, 1984).

For almost 50 years, many attempts have been made to predict some complex soil properties from some easily available soil properties using empirical models. In soil science, such empirical models are named pedotransfer functions (MacDonald, 1998; Krogh *et al.*, 2000). Up to now many of the pedotransfer functions have been developed to predict various soil properties. MacDonald (1998) developed two pedotransfer functions to predict soil CEC based on soil OC and soil clay (CL) as CEC = 2.0 OC + 0.5 CL and CEC = 3.8 OC + 0.5 CL for Quebec and Alberta soil state in Canada, respectively. Seilsepour and Rashidi (2008a) studied Varamin soils in Iran and proposed a pedotransfer function to predict soil CEC based on soil OC and soil pH as CEC = 26.76 + 8.06 OC – 2.45 pH with $R^2$ = 0.77. Seilsepour and Rashidi (2008b) also predicted soil CEC from soil OC using the pedotransfer function CEC = 7.93 + 8.72 OC with $R^2$ = 0.74 for Varamin soils in Iran. Moreover, the US Salinity Laboratory (USSL) developed one of the earlier pedotransfer functions to predict soil exchangeable sodium percentage (ESP) from soil sodium adsorption ratio (SAR) as ESP = – 0.0126 + 0.01475 SAR for US soils (Richards, 1954). Besides, Rashidi and Seilsepour (2008a) proposed a pedotransfer function to predict soil ESP based on soil SAR as ESP = 1.95 + 1.03 SAR with $R^2$ = 0.92 for Varamin soils in Iran. Furthermore, Al-Busaidi and Cookson (2003) predicted soil SAR from soil EC using the pedotransfer function SAR = 0.464 EC +

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7.077 with $R^2$ = 0.83 for saline soils in Oman. Rashidi and Seilsepour (2008b) also developed a pedotransfer function to predict soil SAR based on soil EC as SAR = 1.91 + 0.68 EC with $R^2$ = 0.69 for Varamin soils in Iran.

Since, the above pedotransfer functions have been derived from different zone soils, the general pedotransfer functions between soil properties may be assumed to be similar to those. However, these pedotransfer functions have been shown not to be constant, but to vary substantially with both solution ionic strength and the dominant clay mineral present in the soil (Shainberg *et al.*, 1980; Nadler & Magaritz, 1981; Marsi & Evangelou, 1991; Evangelou & Marsi, 2003; Rashidi & Seilsepour, 2008a). Therefore, the pedotransfer functions are not constant and should be determined directly for the soils of interest.

In view of the fact that previous researches report a relationship between soil OC and soil TN, soil OC can be used to approximate or estimate soil TN. Therefore, the specific objective of this study was to develop a TN pedotransfer function based on OC for calcareous soils of Varamin region in Iran and to verify the developed pedotransfer function by comparing its results with those of the laboratory tests.

## MATERIALS AND METHODS

**Experimental procedure.** One hundred and three soil samples were taken at random from different fields of experimental site of Varamin, Iran. The site is located at latitude of 35°-19'N and longitude of 51°-39'E and is 1000 m above mean sea level, in arid climate in the center of Iran. The soil of the experimental site was a fine, mixed, thermic, Typic Haplocambids clay-loam soil.

In order to obtain required parameters for determining a soil TN pedotransfer function, some soil physical and chemical properties i.e., sand, silt, clay, organic carbon and total nitrogen (% by weight) of the soil samples were measured using laboratory tests as described by the Soil Survey Staff (1996).

Also, in order to verify the soil TN pedotransfer function by comparing its results with those of the laboratory tests, fifteen soil samples were taken at random from different fields of the experimental site. Again, sand, silt, clay, organic carbon and total nitrogen (% by weight) of the soil samples were determined using laboratory tests as described by the Soil Survey Staff (1996).

**Regression model.** A typical linear regression model is shown in Equation 1:

$$Y = k_0 + k_1X \qquad (1)$$

Where

Y = Dependent variable, for example TN of soil.

X = Independent variable, for example OC of soil.

$k_0$, $k_1$ = Regression coefficients.

In order to develop the soil TN pedotransfer function based on soil OC, a linear regression model as Equation 1 was suggested.

**Statistical analysis.** A paired samples t-test and the mean difference confidence interval approach were used to compare the soil TN values predicted using the soil TN pedotransfer function with the soil TN values measured by laboratory tests. The Bland-Altman approach (1999) was also used to plot the agreement between the soil TN values measured by laboratory tests with the soil TN values predicted using the soil TN pedotransfer function. The statistical analyses were performed using Microsoft Excel (Version, 2003).

## RESULTS

Physical and chemical properties of the one hundred and three soil samples used to determine the soil TN pedotransfer function are shown in Table I. Physical and chemical properties of 15 soil samples used to verify the soil TN pedotransfer function are also shown in Table II.

The p-value of independent variable, Coefficient of Determination ($R^2$) and Coefficient of Variation (C.V.) of the soil TN pedotransfer function were 7E–41, 0.83 and 9.5%, respectively. Based on the statistical result, the soil TN pedotransfer function was judged acceptable. The soil TN pedotransfer function is given in equation 2;

$$TN = 0.026 + 0.067\ OC \qquad (2)$$

## DISCUSSION

A paired samples t-test and the mean difference confidence interval approach were used to compare the soil TN values predicted using the soil TN pedotransfer function with the soil TN values measured by laboratory tests. The Bland-Altman approach (1999) was also used to plot the agreement between the soil TN values measured by laboratory tests with the soil TN values predicted using the soil TN pedotransfer function.

The soil TN values predicted by the soil TN pedotransfer function were compared with the soil TN values determined by laboratory tests and are shown in Table III. A plot of the soil TN values determined by the soil TN pedotransfer function and laboratory tests with the line of equality (1.0: 1.0) is shown in Fig. 1. The mean soil TN difference between two methods was -0.002% (95% confidence interval: -0.008 & 0.004%; P = 0.510). The standard deviation of the soil TN differences was 0.011%. The paired samples t-test results showed that the soil TN values predicted with the soil TN pedotransfer function were not significantly different than that measured with laboratory tests. The soil TN differences between these two methods were normally distributed and 95% of these differences were expected to lie between $\mu+1.96\sigma$ and $\mu-1.96\sigma$, known as 95% limits of agreement (Bland & Altman, 1999; Rashidi & Gholami, 2008; Rashidi & Seilsepour, 2008a, b; Seilsepour & Rashidi, 2008a, b). The 95% limits of agreement for comparison of soil TN determined with

**Table I. The mean values, Standard Deviation (S.D.) and Coefficient of Variation (C.V.) of soil physical and chemical properties of the one hundred and three soil samples used to develop the soil TN pedotransfer function**

| Parameter | Minimum | Maximum | Mean | S.D. | C.V. (%) |
|---|---|---|---|---|---|
| Sand (%) | 14.0 | 44.0 | 33.1 | 6.31 | 19.1 |
| Silt (%) | 30.0 | 56.0 | 45.3 | 4.13 | 9.12 |
| Clay (%) | 9.00 | 50.0 | 22.0 | 6.65 | 30.2 |
| pH | 7.00 | 8.10 | 7.50 | 0.27 | 3.60 |
| Organic carbon (%) | 0.31 | 1.60 | 0.77 | 0.36 | 47.1 |
| Total nitrogen (%) | 0.04 | 0.13 | 0.08 | 0.03 | 34.1 |

**Table II. The mean values, Standard Deviation (S.D.) and Coefficient of Variation (C.V.) of soil physical and chemical properties of the fifteen soil samples used to verify the soil TN pedotransfer function**

| Parameter | Minimum | Maximum | Mean | S.D. | C.V. (%) |
|---|---|---|---|---|---|
| Sand (%) | 10.0 | 34.0 | 24.1 | 5.87 | 24.4 |
| Silt (%) | 40.0 | 56.0 | 48.2 | 4.40 | 9.13 |
| Clay (%) | 18.0 | 50.0 | 28.2 | 7.90 | 28.0 |
| pH | 7.00 | 8.00 | 7.31 | 0.33 | 4.51 |
| Organic carbon (%) | 0.25 | 1.70 | 0.77 | 0.42 | 54.8 |
| Total nitrogen (%) | 0.05 | 0.14 | 0.08 | 0.03 | 35.8 |

**Table III. Chemical properties of soil samples used in evaluating the soil TN pedotransfer function**

| Sample No. | OC | TN (%) | |
|---|---|---|---|
| | (%) | Laboratory test | Pedotransfer function |
| 1 | 0.25 | 0.05 | 0.04 |
| 2 | 0.40 | 0.07 | 0.05 |
| 3 | 0.45 | 0.05 | 0.06 |
| 4 | 0.50 | 0.05 | 0.06 |
| 5 | 0.53 | 0.07 | 0.06 |
| 6 | 0.56 | 0.07 | 0.06 |
| 7 | 0.60 | 0.07 | 0.07 |
| 8 | 0.64 | 0.08 | 0.07 |
| 9 | 0.66 | 0.08 | 0.07 |
| 10 | 0.70 | 0.06 | 0.07 |
| 11 | 0.73 | 0.07 | 0.08 |
| 12 | 1.00 | 0.08 | 0.09 |
| 13 | 1.30 | 0.13 | 0.11 |
| 14 | 1.50 | 0.12 | 0.13 |
| 15 | 1.70 | 0.14 | 0.14 |

laboratory test and the soil TN pedotransfer function were calculated at -0.024 and 0.020% (Fig. 2). Thus, soil TN predicted by the soil TN pedotransfer function may be 0.024% lower or 0.020% higher than soil TN measured by laboratory test. The average percentage differences for soil TN prediction using the soil TN pedotransfer function and laboratory test was 12.4%.

In conclusion paired samples t-test results indicated that the difference between the soil TN values predicted by the soil TN pedotransfer function and measured by laboratory tests were not statistically significant ($P > 0.05$). Therefore, the soil TN pedotransfer function can provide a short, simple and economical method to estimate soil TN.

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**Fig. 1. Measured TN and predicted TN using the soil TN pedotransfer function with the line of equality (1.0: 1.0)**

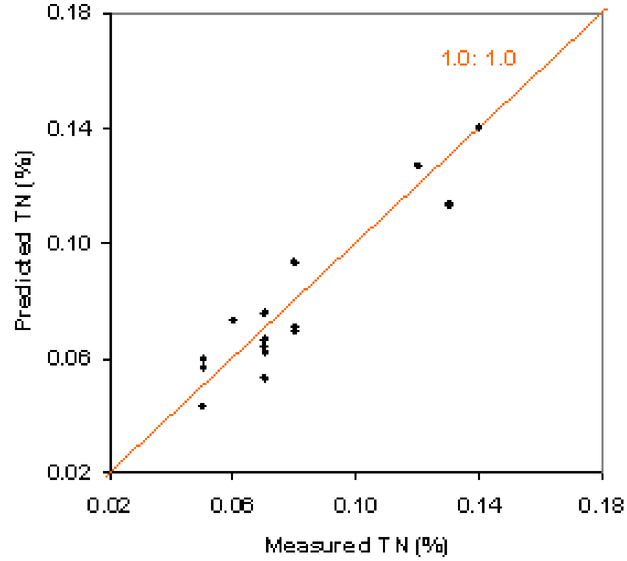
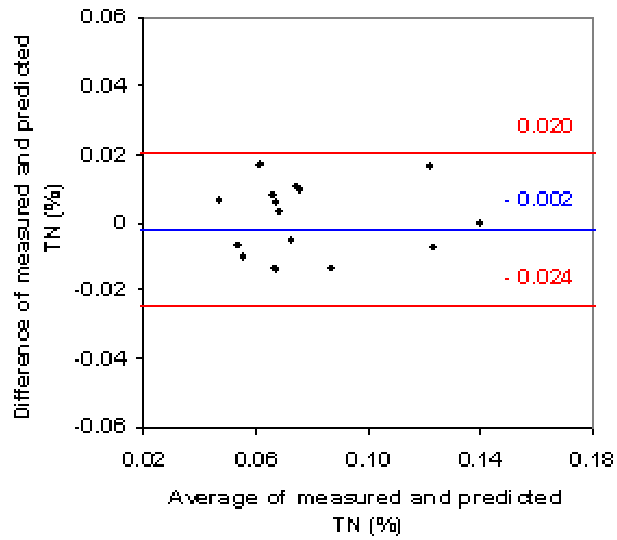



**Fig. 2. Bland-Altman plot for the comparison of measured TN and predicted TN using the soil TN pedotransfer function; the outer lines indicate the 95% limits of agreement (-0.024, 0.020) and the center line shows the average difference (-0.002)**

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