



Across a landscape, soil texture controls the optimum rate of N fertilizer for maize production



Noura Ziadi^{a,*}, Athyna N. Cambouris^b, Judith Nyiraneza^c, Michel C. Nolin^b

^a Agriculture and Agri-Food Canada, 2560 Hochelaga Boulevard, Quebec City, Quebec, Canada G1V 2J3

^b Pedology and Precision Agriculture Laboratories, Agriculture and Agri-Food Canada, Canada

^c Agriculture and Agri-Food Canada, 440 University Avenue, Charlottetown, Prince Edward Island, Canada C1A 4N6

ARTICLE INFO

Article history:

Received 16 November 2012

Received in revised form 28 March 2013

Accepted 29 March 2013

Keywords:

Economic optimum N rate

Residual soil nitrate

N fertilizer rate

Maize yield

ABSTRACT

In maize (*Zea mays* L.) production, appropriate N management needs to consider the specific relations between soil texture, growing season characteristics, and N fertilizer rates. Our main objective was to assess the interaction effect of soil texture (clay, clay loam, and fine sandy loam), and N fertilizer rates (0 to 250 kg N ha⁻¹) on maize N response, soil N availability, and residual soil nitrate (RSN) at harvest. The study was conducted over three years (2000–2002) on a 15-ha field near Montreal (Canada). Crop responses parameters included yield, N uptake, and economic optimum N rate (Nop). Soil and crop-based measures of soil N availability indices were composed of nitrate desorbed from ion exchange membranes measured before (AEM-N₁) and after seeding (AEM-N₂). The effects of N fertilization, soil texture (fine sandy loam > clay loam > clay), were highly significant on maize yield and N uptake. Averaged across years, Nop was 181, 161, and 125 kg N ha⁻¹ in the clay, clay loam, and fine sandy loam, respectively. Estimated RSN at Nop (13–77 kg NO₃-N ha⁻¹) were much lower than the measured ones (22 to 173 kg NO₃-N ha⁻¹). Nitrogen rate equivalent to Nop would have allowed decreasing RSN by 100 kg NO₃-N ha⁻¹. Variable rate N application according to soil texture and to the Nop can reduce input production costs and therefore environmental risks by decreasing RSN.

Crown Copyright © 2013 Published by Elsevier B.V. All rights reserved.

1. Introduction

In high N demanding crops such as maize (*Zea mays* L.), N fertilizer represents an important input cost and yield increases are observed following N fertilizer applications (Ziadi et al., 2008; Nyiraneza et al., 2009; Gagnon and Ziadi, 2010; Gagnon et al., 2012). In Canada, 1.2 million hectares were cropped to maize in 2010 mostly in Ontario and Quebec (Statistics Canada, 2011). Applying N fertilizer that exceeds crop N needs has been linked to environmental concerns because unused N can be lost by leaching, denitrification or volatilization (Chantigny et al., 1998; Gagnon et al., 2011; Ziadi et al., 2012). Indeed, studies conducted in Quebec on maize production reported that fertilizer N recoveries vary between 40 to 65% of applied N (Tran et al., 1997; Isfan et al., 1995; Nyiraneza et al., 2010a), and that the economic optimum N rate is below the N rate applied (Gagnon and Ziadi, 2010). Painchaud (1997) reported that nitrate concentration in the tributaries of the St. Lawrence (Eastern Canada) is increasing and Macdonald (2000)

estimated that about 41% of the Canadian farmland area shows intermediate to high risk of water contamination by N.

Nitrate leaching is largely influenced by the amounts of mineral N in the top soil at harvest (Roth and Fox, 1990; Liang et al., 1991; Ziadi et al., 2012) and residual soil nitrate (RSN) is largely affected by N fertilizer rates (Bélanger et al., 2003; Gagnon and Ziadi, 2010; Ziadi et al., 2012), N uptake during growing season, and climatic conditions (Jokela and Randall, 1989; Liang and Mackenzie, 1994a; Dessureault-Rompere et al., 2010a,b; St. Luce et al., 2011). Roth and Fox (1990) reported RSN values ranging from 41 to 138 kg NO₃-N ha⁻¹ to a depth of 1.2 m in the fall following a maize crop fertilized at economic N rate. In a recent study conducted in Eastern Canada, Ziadi et al. (2012) reported NO₃-N ha⁻¹ contents (0–0.90 m) varying between 0 and 104 kg N ha⁻¹ at maize harvest.

Because crop yield and N use efficiency are highly influenced by many factors, improved N management practices that reduce NO₃⁻ loss should be site-specific based (Bouma, 1999; Andraski et al., 2000). Nitrogen requirements for maize is influenced by previous crop, soil mineral N content in spring, soil organic matter (SOM), clay content, landform and soil drainage (Franzluebbers et al., 1995; Jarvis et al., 1996; St. Luce et al., 2011). These factors varied largely within-field and are spatially dependent in different regions including the St. Lawrence lowlands, Quebec, Canada (Nolin et al., 1996,

* Corresponding author. Tel.: +1 418 210 5052; fax: +1 418 648 2402.

E-mail address: noura.ziadi@agr.gc.ca (N. Ziadi).

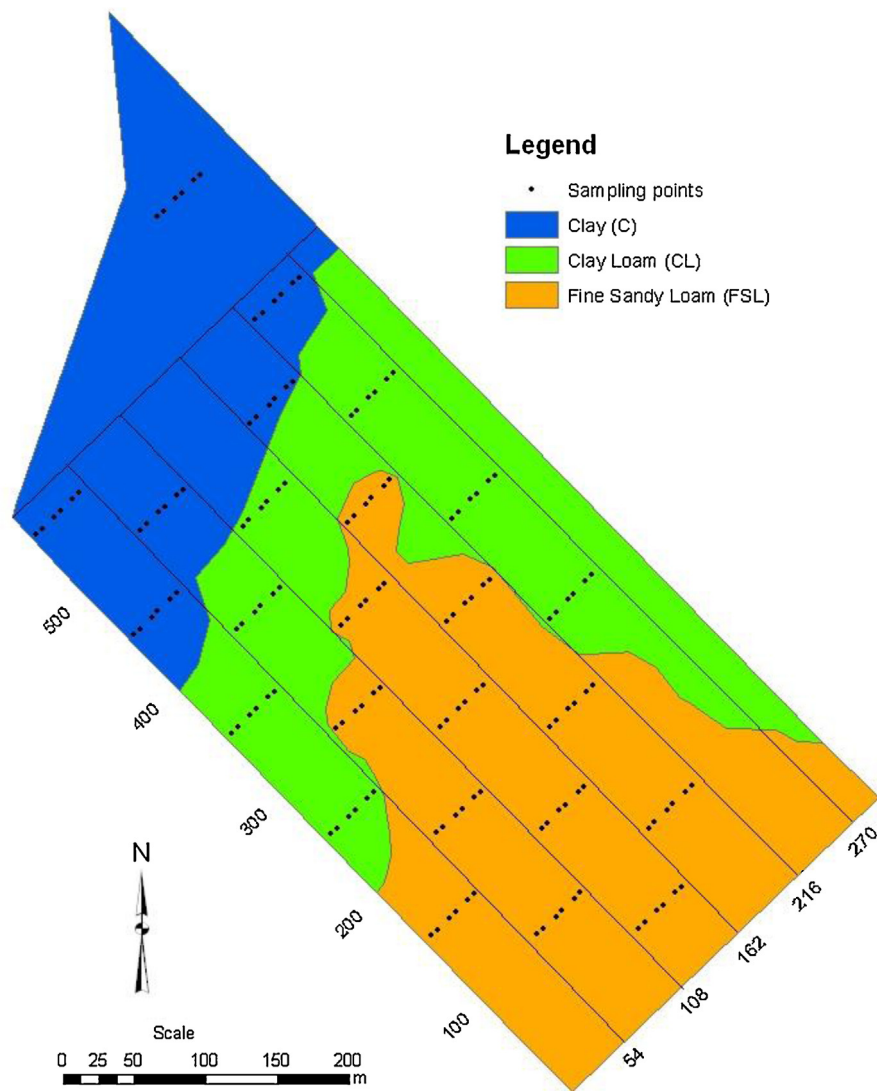


Fig. 1. Soil management zones based on soil texture showing sampling points.

1999). Despite these variations and high within-field variability in crop N uptake (Kachanoski and Fairchild, 1996), N fertilizer recommendation for maize, remain however uniform in most areas of USA and Canada (Ontario Ministry of Agriculture and Rural affairs (OMARA), 1998).

Soil texture is another important factor that influences soil productivity and yield potential by controlling water supply (Cambouris et al., 2006), crop N requirement (Oberle and Keeney, 1990), and N mineralization (Hassink, 1994; Simard et al., 2001; St. Luce et al., 2011). Soil texture was classified as the most important component in soil fertility (Nolin et al., 1989; Leclerc et al., 2001).

Crop response to N fertilizer has previously been described using different models by means of empirical data in the USA (Osterhaus et al., 2008; Laboski et al., 2008) and in Eastern Canada for forage crop (Ziadi et al., 2000), potatoes (Bélanger et al., 2000) and for maize (Sarr et al., 2008; Nyiraneza et al., 2010b; Gagnon and Ziadi, 2010) but additional information is still needed to show how the specific relationships between soil textural class, and N fertilizer rates impact maize N response. The objective of this three year study was to evaluate the within-field interaction effect between soil texture and N fertilizer on maize N response, soil N availability and residual soil nitrate at harvest (RSN).

2. Materials and methods

2.1. Site description

The study was carried out for three years (2000–2002) in a 15-ha field (270 m × 555 m), located at St. Marc-sur-Richelieu (45°43' N, 73°14' W) near Montreal, QC, Canada (Simard et al., 2001). Krigged map of surface clay content (Fig. 1) done with ArcGIS (version 10.3) was used to delineate the three management zones (MZ). When the clay content was ≤20%, the MZ was referred to fine sandy loam (FSL), when the clay content was >20% and ≤40%, the MZ was referred to clay loam (CL), and when the clay content was >40%, the MZ was referred to clay (C).

Created MZs showed significant differences in the mean values of chemical and physical characteristics of the soil surface such as clay and organic matter (OM) contents (Fig. 1, Table 1). As reported in Table 1, clay content ranged from 104 to 586 g kg⁻¹ (CV=52%) and sand from 27 to 724 g kg⁻¹ (CV=45%). The OM content was moderately variable (CV=22%) ranging from 16 to 57 g kg⁻¹. Soil NO₃-N content (0–0.20-m depth) was also moderately variable (CV=16%) and ranged from 13 to 210 kg ha⁻¹ (Table 1). Within-field variability of soil attributes (Table 1) is larger than reported for other intensively sampled fields from the St-Lawrence Lowlands

Download English Version:

<https://daneshyari.com/en/article/4510199>

Download Persian Version:

<https://daneshyari.com/article/4510199>

[Daneshyari.com](https://daneshyari.com)