Northern New York
Agricultural Development Program

FACT SHEET

How Soil Type and Drainage Affect Corn Nitrogen Response

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Why Study the Factors Affecting Crop N Response?

By studying how soil type, field drainage and other factors influence a crop's response to fertilizer, researchers can develop guidelines that may allow farmers to reduce the expense and environmental impact of using greater amounts of fertilizer, manure and other crop inputs.

Introduction

How do soil type and differences in soil texture and drainage affect corn's response to site-specific application of nitrogen (N)? Cornell University researchers undertook a study to answer this question for two soil types under a variety of early season drainage conditions. Their evaluation assessed crop response to N fertilizer and soil nitrate levels over a three-year period.

The objective of this study was to quantify the effects of imposed drainage conditions on early season soil water conditions and nitrate levels, corn yield and crop N response for two soil types that imperfectly drain in their natural state.

Past Research:

The researchers working on this study began their work with the following earlier research conclusions in mind:

- variable-rate application equipment and GPS technology allow for site-specific application of N fertilizer (Robert, 2002)
- soil sampling, historical yield records, and protein information can be used to determine the amount of N removed and subsequently the amount of site-specific N needed (several studies)
- soil water holding capacity and seasonal weather factors strongly affect N management (Moore and Tyndale-Briscoe, 1999)
- tillage, drainage, crop type, soil organic matter content and weather factors all affected N dynamics in humid regions (Dinnes et al., 2002)
- poorly drained areas justify higher N rates only in excessively wet years (Sogbedji et al., 2001; Katsvairo et al., 2003a,b)

- early season rainfall and temperature strongly affect the availability of mineralized soil N (Balkcom et al., 2003)
- the Pre-Sidedress Nitrogen Test (PSNT) is designed for use with precise N management on corn (several studies)
- studies that have shown use of PSNT to result in lower N fertilizer rates and nitrate leaching losses with crop yields comparable to traditional yield goal based methods suggests that economic and environmental benefits could result from seasonal adjustment of N fertilizer rates through late-spring assessment of soil N conditions.

Methods:

Sixteen research plots with drain lines at 0.9-m (35.43 in) depth were established on both a glacio-lacustrine Muskellunge clay loam soil and a Stafford loamy fine sand-soil at the Cornell Baker Research Farm at Willsboro. An impermeable PVC geomembrane surrounded the plots. Calibration plots - one for each soil type - were maintained nearby. Silage yields were used to determine optimum fertilizer rates and crop yields.

Alfalfa was plowed on the clay loam plots in Fall 1991; grass was plowed on the loamy sand plots in Spring 1992. Corn was planted in mid-May 1992, 1993 and 1994. Row spacing was 0.76 m/29.92 inches; targeted plant density was 29,000 seeds/acre. Recommended herbicides were applied pre-emergence on May 19, 1992; May 13, 1993; and May 20, 1994.

Two drainage regimes - drained and undrained - were established. In 1993 and 1994, the undrained plots received supplemental irrigation to establish more distinct soil water conditions as compared to the drained plots.

Three N fertilizer rates were applied to plots:

- low N treatment = only starter fertilizer band-applied at a rate of 20 lbs N/acre with a planter
- intermediate N treatment = starter fertilizer applied at a rate of 20 lbs N/acre plus sidedressing at a rate (generally 70 lbs N/acre) based on PSNTs taken in mid-June in each study year
- high N treatment = a starter rate of 20 lbs N/acre plus 100 lbs N/acre as sidedress, representing an eventual maximum N application for both soil types.

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A John Blue injector was used to deliver urea ammonium nitrate 80 mm/3.15 in below the soil surface in alternate corn interrows as sidedress.

To measure differences in soil water conditions resulting from the different drainage systems, soil water potential was monitored at least weekly during the early growing season to the date of sidedressing. Soil nitrate concentrations were determined weekly.

Results

Growing season rainfall totals for 1992, 1993 and 1994 respectively were 234/9.21, 232/9.13, and 332/13.07 mm/in. The 30-year mean for Willsboro was estimated at 358 mm/14.09 in. The effect of rainfall on the leaching of soil nitrates was generally measurable within one to two days.

On average for both soil types, the undrained regime had higher soil water potentials than the drained regime. During the period between planting and sidedress, the 225 mm/8.85 in depth had higher potentials than the 75 mm/2.95 in depth. Overall, the clay loam soil experienced higher soil water potentials and experienced longer periods of saturation under the undrained regime than the loamy sand soil. For example, in 1992 and 1993 at the 225 mm/8.85 in depth the clay loam under the undrained treatment showed 11 and seven days of saturation compared to zero days of saturation for the loamy sand. Field saturation occured less often, if at all, under the drained conditions on both soils.

Soil nitrates

The highest soil nitrate concentrations - 13-33 mg NO_3-N kg-1 - were measured at the clay loam site in Spring 1992. Researchers presume this concentration is associated with high N mineralization rates from the alfalfa plowdown of the previous fall.

Mean soil nitrate measurements for subsequent early Spring seasons at the clay loam site and all three seasons at the loamy sand site were all lower - less than 20 mg NO_3-N kg-1.

Researchers attribute nitrate levels that dramatically decreased from a high point in mid-May 1992 through the following three weeks to extended periods of soil saturation during late May and early June. They suggest the net effect of soil drainage conditions on denitrification and leaching was generally minimal on both soils drained and undrained.

On average for both soil types, the undrained regime had higher soil water potentials that the drained regime.

Researchers note that the PSNT accurately predicted crop N needs in five of six comparisons and suggested a conservative N application rate that proved to provide yields comparable to using a greater N application.

Conclusions

Overall response to N fertilizer application was not significant due to a high interaction with year effects. Presumably, N carryover from previous sod crops provided high levels of N, especially for the corn grown on the clay loam plots. In 1992, low rainfall resulted in lower soil nitrate losses in early May and June. A higher response to N was measured in 1994 with a wet spring. Researchers say this response aligns with a study by Sogbedji et al. in 2001 that showed that high precipitation in late spring may greatly increase crop N response, particularly in finer-textured soils.

Average yield values for drained versus undrained treatments were the same in 1992 and 1993 and were significantly different only for the clay loam in the wet 1994 year. Losses in corn yield for 1994 for the clay loam were 19 percent for grain yield and 29 percent for silage yield. The corn grown on loamy sand in 1994 showed losses of 12 percent for grain and 8 percent for silage.

Researchers note that the PSNT accurately predicted crop N needs in five of six comparisons and suggested a conservative N application rate that proved to provide yields comparable to using a greater N application. The PSNT was only inadequate in the wet year on clay loam, on which yields were lower than on a test plot using full N recommendation.

This study produced the following conclusions:

- soil nitrate levels were linked to precipitation and soil water conditions
- periods of extended soil wetness resulted in soil nitrate losses, presumably due to leaching and denitrification
- the potential benefits of site-specific application of N sidedress fertilizer based on soil type or drainage conditions are moderate
- higher N rates may be justified on clay loam (finer-textured) soils in years with high late-spring precipitation
- estimating year-to-year variation in N fertilizer demand appears to provide greater opportunities for optimizing N management for corn production than using variable rates within fields.

Table 1. Mean grain and silage yields from the drainage sites on clay loam and loamy sand soils, and optimum N rates.

	Grain - bu/ac+		Silage - tons/ac*		
CLAY LOAM	**drained**	**undrained**	**drained**	**undrained**	**Opt. N rate**
1992	173.3	178.0	24.8	25.0	0
1993	165.3	168.5	19.8	20.8	66.3#
1994	152.6	124.0	18.5	13.2	132.7#
LOAMY SAND SITE					
1992	160.5	162.1	22.0	21.6	10.9#
1993	173.3	171.7	20.2	20.7	96.3#
1994	174.9	154.2	20.2	18.7	142.7#

+ Grain yields at 15% moisture content
** Silage yields at 65% moisture content*
 # Optimum N rate at lbs/acre

Nitrate Leaching as Affected by Manure Application Timing and Soil Type

Project Sponsors

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