DIFFERENCES IN NITROGEN MINERALIZATION ACROSS A LANDSCAPE

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Nitrogen management is an important aspect for economic production of sugar beet. Nitrogen in the organic matter contributes over 50 % of the nitrogen used to raise sugar beet. Yet this information is not used for making fertilizer N guidelines. Soils in the Southern Minnesota Beet Sugar Cooperative growing area vary in organic matter concentrations from 2 to 10 % within a single production field. Little information exists on the within field variability of N mineralization from soil organic matter. There is a need to at least acquire knowledge of organic matter N mineralization variability to determine if within field N rates should be altered based management zones delineated by soil organic matter content.

Nitrogen (N) for the production of sugar beet comes primarily from three sources: 1) Residual soil nitrate-N left after the previous crop; 2) Nitrogen fertilizer application; and 3) Nitrogen mineralization from previous crop residue and soil organic matter. Current N fertilizer recommendations for sugar beet account for sources 1 and 2 (Lamb et al., 2001). Adjustments to the N fertilizer recommendations to account for some previous crops, such as legumes, are suggested in many situations. However, N mineralization from soil organic matter, which may include previous crop residues, is not specifically accounted for.

Nitrogen mineralization has been difficult to access and include in N recommendations (Rice and Havlin, 1994). Many attempts have been made to develop an indices of N mineralization, but the methodologies to do so have been elusive. These attempts have included laboratory methods of chemical extractions (Keeney, 1982) and incubation studies (Stanford and Smith, 1972); field methods of buried bag (Eno, 1960), ion exchange resins or membranes (Schnabel, 1983; Qien et al., 1993), and soil nitrate-N testing (Magdoff et al., 1984); and plant tissue testing during the growing season (Rice and Havlin, 1994). Laboratory incubations have been invaluable in describing the relationship of N mineralization to temperature and moisture (Stanford et al., 1973; Stanford and Epstein, 1974), but their applicability to field conditions is questioned. Plant tissue testing can be very labor intensive and expensive. Gelderman et al. (1988) reported poor correlations between laboratory chemical extractions and field estimates of N mineralization in 69 winter wheat fields in North Dakota and South Dakota.

Ion exchange resin and membranes have shown promise in estimating N mineralization under actual soil and field conditions. Ion exchange membranes have been useful in measuring relative N mineralization among treatments, but absolute N mineralization is not possible because there is no specific soil volume associated with them (Kolberg et al., 1997). DiStefano and Gholz (1986) combined intact soil cores with ion exchange resin (IER) to measure in situ N mineralization in natural field conditions. The method was adapted for use in forest and rangeland ecosystems (Binkley et al., 1992; Hook and Burke, 1995). Kolberg et al., (1999) adapted this method for use in a dry land agroecosystem in Colorado. One of the issues with IER and intact soil cores is how many samples are needed to achieve an acceptable level of precision. Kolberg et al. (1997) found that 5-7 cores were necessary to achieve a precision of +/- 1.5 mg N kg^{-1} soil at a 20% confidence level. The primary limitation to the number of samples to use is the labor and time in the laboratory analysis of the IER.

This report will concentrate on the process to evaluate the mineralization of nitrogen from soils located in different parts of a grower's field.

Materials and Methods

To meet the objective, a technique was used that was developed by Dr. Albert Sims for Minnesota conditions that measures, in situ, inorganic nitrogen released from organic matter. This technique involves taking a 2 inch diameter soil cores to a depth of 10 inches with a plastic lined sampler. The soil cores contained inside the plastic liner were removed from the soil, a bag of ion exchange resin was placed in the bottom of the core, but inside the plastic liner and the entire unit, soil core, plastic sleeve, and resin bag, were put back in the ground hole. The plastic sleeve eliminates lateral movement of mineralized N and kept plant roots from accessing the N. Water percolating through the soil core leaches soluble N, mostly nitrate-N, passing through the resin bag where nitrate-N and ammonium-N was captured by the ion exchange resin.

To understand how mineralization changes across the soil organic matter delineated zones through the growing season, several sets of soil cores plus resin bags were installed in several zones in the spring immediately after planting in three production fields in the Southern Minnesota Beet Sugar Cooperative growing area. Periodically through the growing season (6-7 week intervals), soil cores were retrieved and analyzed for nitrate- and ammonium-N, Table 1. Resin bags from the soil cores were retrieved along with resin bags associated with soil cores still remaining in the field and analyzed for nitrate- and ammonium-N. For those soil cores left in the field, fresh resin bags replaced those removed during the retrieval process. At each of four sampling times during the growing season nine soil cores plus resin bags were harvested.

Table 1. Field and sampling dates for mineralization cores in 2009.

Field	Initial	Date 1	Date 2	Date 3	Date 4
P09	May 19	June 19	July 17	August 18	Sept. 21
M09	May 19	June 19	July 17	August 18	Oct. 1
J09	May 19	June 19	July 17	August 18	Sept. 29

Results and Discussion

Three production fields in the Southern Minnesota Beet Sugar Cooperative growing area were used for this study. The fields were grid soil sampled and management zones were developed based on organic matter. The criteria for the zones were zone 1 < 3.0 %, zone 2 = 3.0 to 4.0 %, zone 3 = 4.01 to 5.0 %, zone 4 = 5.01 to 7.0 %, and zone 5 = > 7.0 %. Each field had different number of management zones, Table 2. The soil test information indicates that there is little relationship between organic matter and soil test nitrate-N, P, and K.

Table 2. Soil test results for each field and organic matter zone in fall 2008.

		Organic matter	pH	Nitrate-N 0-4 ft.	Olsen P	K
Field	OM zone	%		lb/A	ppm	Ppm
P09	1	2.8	7.9	92	6	116
P09	2	4.5	7.2	26	39	155
P09	3	4.5	8.0	31	4	135
M09	1	3.2	7.1	36	4	64
M09	2	3.1	7.2	37	4	65
M09	3	3.7	7.2	38	5	75
M09	4	5.8	7.8	44	5	90
M09	5	16.1	7.3	171	6	158
J09	3	4	7.7	21	4	171
J09	4	5.1	7.7	103	6	154

The P09 field had 3 zones mapped in it. Zones 2 and 3 had similar organic matter concentrations. At the P09 field N mineralized during 2009 increased over the growing season, Figure 1. Zone 3 mineralized approximately 60 lb N/A from the initial sampling, May 19, to the first sampling, June 19. After June 19, the rate of mineralization slowed. Zone 2 did not mineralize much between the initial sampling and June 19. After that time 60 lb N/A was found between sampling 1 and 3. For some unknown reason the amount of mineralization decreased between sampling dates 3 and 4. This could be caused by the variability in this procedure or possibly loss of N through denitrification. Zone 1, the zone with the lowest organic matter concentration in this field, only mineralized 20 lb N/A during the growing season.

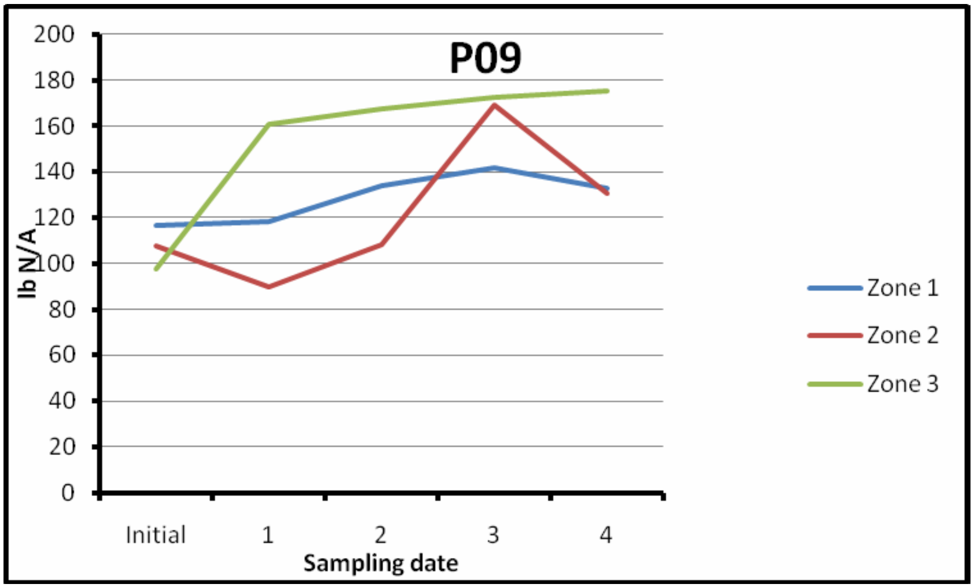

Figure 1. In-situ mineralization of nitrogen in Zones 1 – 3 at the P09 field in 2009.

The M09 site had 5 zones in it. The organic matter ranged from 3.2 to 16.1 % in this field. Zones 1 through 3 mineralized similar amounts from the initial sampling to sampling date 2, Figure 2. After sampling date 3 zones 1 and 2 did not mineralize any more nitrogen. The soils in Zones 1 and 2 mineralized 40 lb N/A in 2009. The core sites for zones 1 and 2 had similar measured organic matter concentrations and thus a similar mineralization. Zone 3 mineralized 95 lb N/A while zone 4 cores mineralized 94 lb N/A but started at a greater level of nitrogen in the cores. Zone 5 had a very high organic matter of 16.1 %. This increase in organic matter caused a greater initial mineralization rate and level but during the growing season the mineralization was reduced. At this time there is no explanation for this.

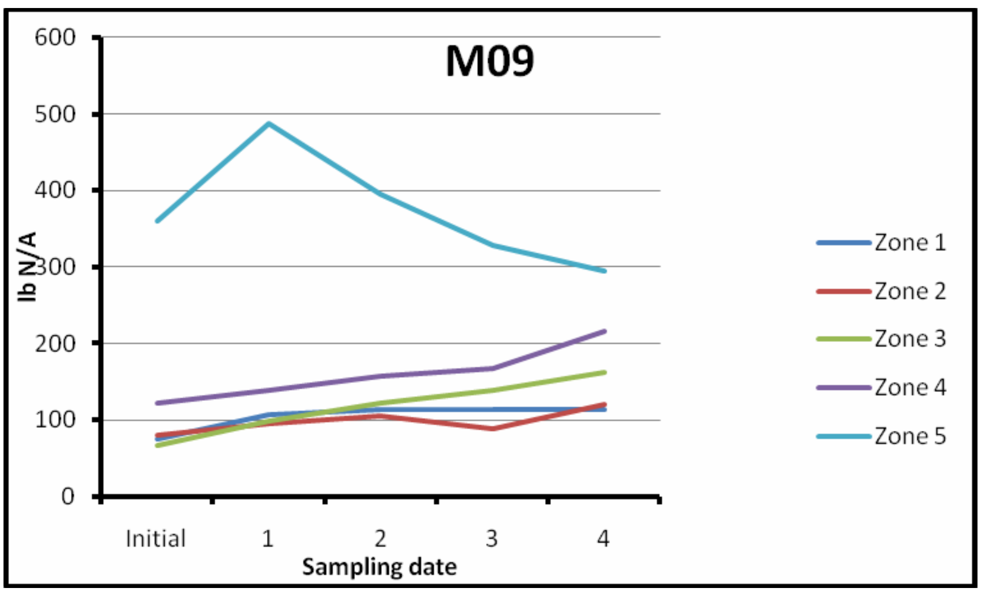

Figure 2. In-situ mineralization of nitrogen in Zones 1 – 5 at the M09 field in 2009.

The J09 field had two management zones in it. Zone 3 mineralized 41 lb N/A during the 2009 growing season while zone 4 mineralized 78 lb N/A. This indicates that in the J09 field the concentration of organic matter did affect the amount of N mineralized.

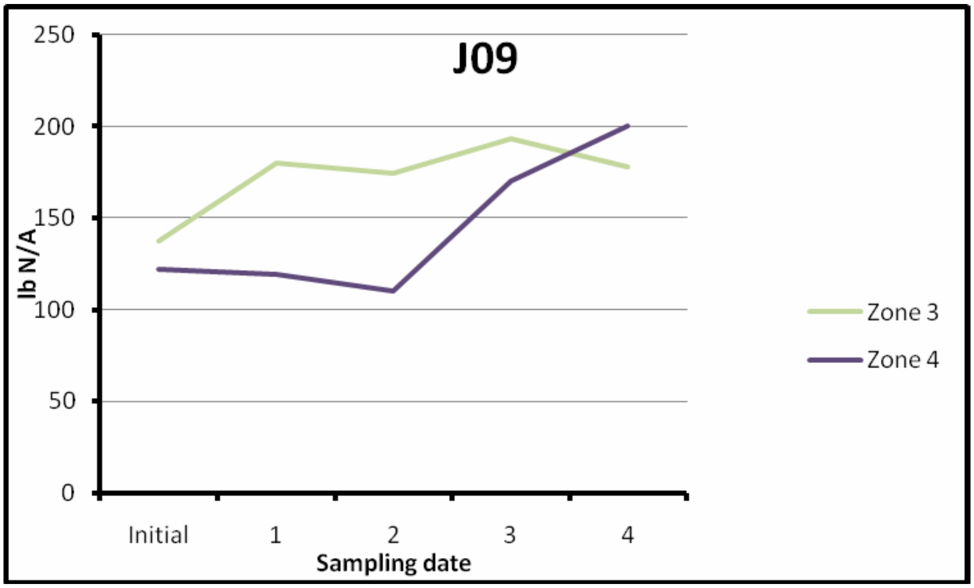

Figure 3. In-situ mineralization of nitrogen in Zones 3 -4 at the J09 field in 2009.

Summary

The data from the 2009 growing season suggests that organic matter concentration does influence the amount of nitrogen mineralized during the growing season particular if the organic is greater than 4.5 to 5 %. Another year of field measurement will be needed to confirm this. If this continues to be true, then adjusting N guidelines for sugarbeet grown in South Central Minnesota should be investigated.

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