

ESTIMATING SOIL NITROGEN MINERALIZATION DURING THE GROWING SEASON IN SUGAR BEET GROWN AFTER CORN, WHEAT, AND SOYBEAN.

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Three major sources of nitrogen (N) contribute to a sugar beet crop: 1) Residual soil nitrate-N left from the previous crop; 2) Fertilizer N; and 3) N mineralized during the growing season from the previous crop residue and soil organic matter. Current fertilizer N recommendations account for only residual soil nitrate-N and fertilizer N (Lamb et al., 2001). Nitrogen credits are given for certain crops grown the year previous to sugar beet which can reduce fertilizer N recommendation. However, N mineralized from the soil organic matter (includes both previous crop residues and less definable organic materials in the soil) are not specifically accounted for.

Nitrogen mineralization has been difficult to assess and include in N recommendations (Rice and Havlin, 1994). Many attempts have been made to develop 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), 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.

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). Kolbert 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 $\pm 1.5 \text{ mg N kg}^{-1}$ 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.

Nitrogen is one of the primary inputs for sugar beet production and has significant consequences if under or over supplied. Under application results in reduced root yield and over application results in reduced root quality. The fertilizer N recommendation for sugar beet was revised in 2000, but many producers, fertilizer dealers, consultants, and cooperative agronomist have questioned if the new recommendations account for variability in soil organic matter or previous crop. The amount of N mineralized from soil organic matter during the growing season varies with the nature of the organic matter, quantity of organic matter, temperature, and moisture. Soil organic matter content is not included in fertilizer recommendations in Minnesota and North Dakota because of the difficulty in quantifying mineralized soil N. An experiment had been initiated at the NWROC to compare previous crops of corn, wheat, or soybean on the N response of sugar beet. This provided an opportunity to examine N mineralization under these different management systems using intact soil cores and IER as described by Kolberg et al. (1997), with some slight modifications.

Objectives

1. Estimate the quantity of N mineralized in sugar beet plots during the growing season.
2. Determine if N mineralized is affected by either previous crop grown or the application of fertilizer N.

Materials and Methods

Field experiments were initiated in 2006 to establish plots of corn, wheat, and soybean which would serve as previous crop treatments for sugar beet grown in 2007 (Sims, 2008). Within a few days after sugar beet was planted, plastic liner tubes (PLT) were placed in rows 2 and 5 (6 row plots) of specific treatments. The PLTs were placed in the sugar beet row to allow normal cultivation without interference. The targeted treatments were previous crops of corn, wheat, and soybean with chisel plow as primary tillage, and 0 and 75 lbs N A⁻¹ fertilizer rates. Following a previous crop of corn, only the 0 N rate received PLTs. Though the actual field experiment consisted of four replications, PLTs were placed in only three replications because of the intense labor requirement in placing, harvesting, processing, and analyzing the samples.

Plastic liner tubes, 2.375 inch i.d. by 12 inches long were contained in a steel soil probe and inserted into the soil to a depth of 6 - 8 inches. The soil slides into the PLT and is extracted from the ground when the probe is extracted. The PLT with the enclosed soil core is removed from the steel soil probe and prepared for reinsertion back into the soil from which it was extracted. Before reinsertion, a nylon bag of ion (anion/cation) exchange resin (IER) is placed at the bottom of the soil core, and a nylon stocking is placed over the entire PLT, soil core, and resin bag. The entire unit is then reinserted into the ground hole from which the soil came (Fig 1). As water moves through the soil core carrying with it N, the PLT prevents lateral movement and forces percolating water and N through and out the bottom of the soil core passing through the nylon bag containing the IER. The resin will capture the nitrate-N and any ammonium-N moving with the water.

At the initial set up of the experiment when PLTs were placed in the field, 24 PLTs were inserted into each plot. Six of the PLTs were harvested immediately and the soil analyzed for nitrate- and ammonium-N to provide estimates of initial inorganic N status. At three times during the growing season, six PLTs were harvested from each plot and the soil core plus the IER bag were stored in the laboratory. Resin bags were stored in the refrigerator and soil cores were frozen until they could be analyzed. Soil cores were thawed then measured, weighed, and a subsample dried to determine moisture at the time of sampling in order to estimate soil bulk density within the soil core. During the analysis phase, soil samples and IER bags were exposed to varying amounts of KCl solution to extract nitrate- and ammonium-N, which were measured using a Latchet Auto Analyzer. At each sample harvest, resin bags from soil cores to remain in the field were also harvested and replaced with fresh IER bags. These IER bags were also stored in the refrigerator and later analyzed for nitrate- and ammonium-N. The IER bag replacement was to reduce contamination of the resin bag with plant roots and help prevent overloading the resin with nitrate- or ammonium-N.

Laboratory data (bulk density, soil nitrate- and ammonium-N, and IER bag nitrate- and ammonium-N) from individual samples were combined within a plot-sampling time. Since the surface area of each core is known, this data can be converted to per acre or hectare equivalence.

Results

Soil conditions during the 2007 growing season were such that N mineralization occurred through out the measured period. Within individual sampling dates, there was no significant differences in inorganic N accumulation among the previous crop treatments though the N tended to be greater following wheat and soybean than following corn (Table 1). Adding 75 lbs. N A⁻¹ as fertilizer prior to planting sugar beet significantly increased the accumulation of inorganic N compared to not applying any fertilizer N (Table 1). Total N mineralization was 43, 55, and 56 lbs N A⁻¹ over the entire growing season following corn, soybean, and wheat, respectively, with no fertilizer N. With the application of 75 lbs. N A⁻¹, total N mineralization was 69 and 79 lbs. N A⁻¹ over the entire growing season following soybean and wheat, respectively.

The rate of N mineralization during the first two-thirds of the growing season was similar following wheat and soybean and both were greater than following corn (Fig 2). Nitrogen mineralization in the last third of the growing season was similar following all previous crops. When 75 lbs. N A⁻¹ was applied as fertilizer, N mineralization rates varied somewhat between previous crops of wheat or soybean, but error bars for mean data points of both previous crops overlap suggesting there is probably not much difference between the two previous crops regardless of whether fertilizer N is applied or not.

The relatively lower N mineralization rate following corn compared to following soybean or wheat was not surprising. However, the similarities following either wheat or soybean were unexpected. Typically, an N credit is given to a crop N requirement when that crop follows soybean. This credit is substantiated by a rather large body of research evidence mostly based on growing corn after either soybean or corn. The data reported in this report, as well as that reported by Sims (2008), suggests that the N credit given for a soybean crop may not be that simple. Much of the data contributing to the N fertilizer recommendations for sugar beet was generated on sugar beet grown after wheat except in the Southern Minnesota Beet Sugar Cooperative region where sugar beet followed corn (Lamb et al. 2001). My data suggests that a 40 lbs. N credit for a previous crop of soybean to a sugar beet crop N fertilizer recommendation may be too generous, especially when compared to sugar beet following wheat.

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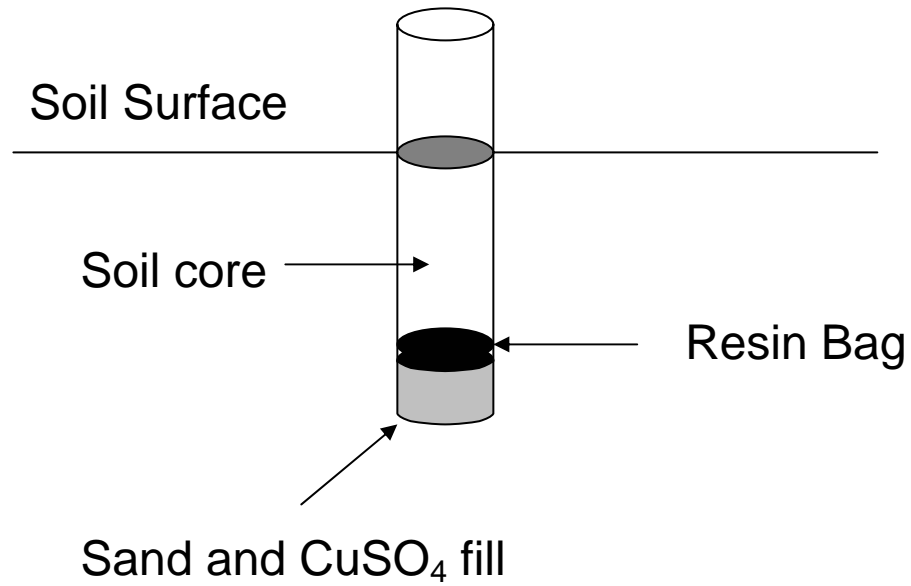


Figure 1. A visualization of the plastic tube (PST), soil core, ion exchange resin bag, and the fill sand combination when placed in the field.

Table 1. Inorganic N accumulation during the 2007 sugar beet growing season when 0 or 75 lbs N A⁻¹ fertilizer was applied after previous crops of corn, soybean, or wheat. Statistics are based on analysis of individual sampling dates.

Previous Crops	N rates	Sampling Day ^δ				Total ^{δδ}
		4 DAP	46 DAP	89 DAP	137 DAP	
	-- lbs N A ⁻¹ --	----- lbs N A ⁻¹ (6.5 inch depth) -----				
Corn	0	26.6	40.5	52.5	70.3	43.3
Soybean	0	29.4	47.7	69.7	83.7	54.7
Soybean	75	72.1	98.2	115.4	141.1	69.3
Wheat	0	29.5	50.7	70.2	85.5	56.0
Wheat	75	54.5	105.0	125.5	133.3	78.7
LSD _(0.05)		29.3	27.4	34.8	24.9	17.5
LSD _(0.10)		23.6	22.1	28.1	20.1	14.1

δ DAP represents Days After Planting

δδ Total represents the total change in inorganic N over the growing season between 4 DAP and 137 DAP.

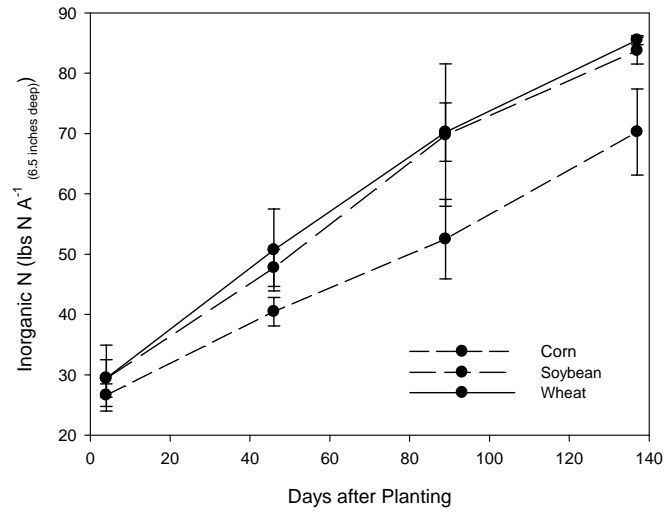


Figure 2. Accumulation of inorganic N during the 2007 sugar beet growing season in plots receiving no N fertilizer and with previous crops of corn, soybean, or wheat.

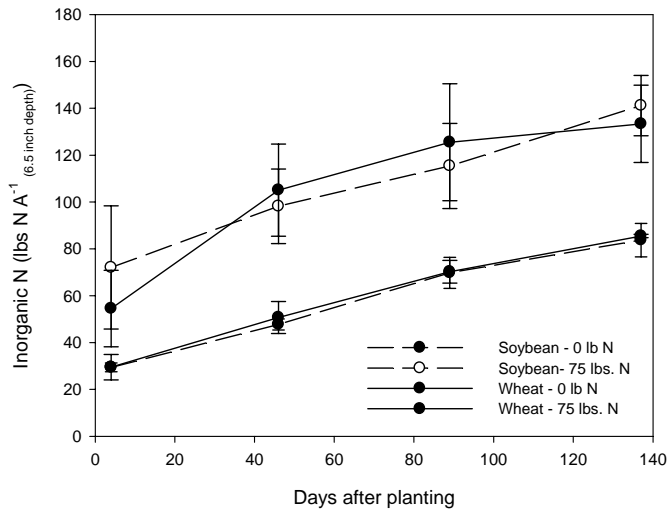


Figure 3. Accumulation of inorganic N during the 2007 sugar beet growing season in plots receiving 0 or 75 lbs N A⁻¹ fertilizer with previous crops of soybean or wheat.