NITROGEN MANAGEMENT IN SUGAR BEET GROWN IN FINER TEXTURED SOILS OF THE RRV

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Nitrogen (N) is an essential nutrient for all plant life and is the most managed nutrient in crop production. Careful management of N in sugar beet production is especially critical. A typical sugar beet crop will accumulate from 180 to 220 lbs. N A^{-1} under non-N limiting conditions (Armstrong and Milford, 1985; Pocock et al., 1990; Duval, 2001). Nitrogen accumulation above this range can severely reduce sugar beet root quality (Armstrong and Milford, 1985; Pocock et al., 1990). However, N accumulation within this range is required for optimum sugar beet production. Root yield is determined by the biomass produced in actively functioning leaves then transported and accumulated in the root. Nitrogen does not increase the conversion efficiency of intercepted light to biomass, but it does increase the size of the leaf canopy that intercepts more light (Armstrong et al., 1983). Light interception and dry matter production increases as the leaf canopy increases up a leaf area index of 3-4.

The sugar beet crop obtains its N from three major sources in the soil; residual inorganic N, N mineralized from the organic material, and applied fertilizer N. Researchers have used labeled non-radioactive N^{15} as a fertilizer source to trace of the fate of the fertilizer N. Sugar beet can acquire N down to a soil depth of at least 4 ft (Biseshart, 1983), but applied fertilizer N may contribute only 40% of the total N accumulated in the beet plant (Lindemann et al., 1983). Frequently the fertilizer uptake efficiency is 50% or slightly higher (Haunold, 1983; Lindemann et al., 1983). The inability of the sugar beet plant to acquire more than 50% of the applied fertilizer is consistent with what has been reported for other crops and reflects the complex dynamics of N in the soil environment. These findings also emphasize the contribution needed from the residual soil N and mineralized N to the sugar beet crop for optimum production. Residual soil N is estimated using soil testing to measure the amount of nitrate-N to either the 2-ft or 4-ft soil depth. The amount of residual soil N is a product of the overall N management strategy used in the entire cropping season as well as environmental factors affecting crop production. Mineralized N reflects several soil characteristics that include temperature, moisture, organic matter content and type, aeration, and microbial population, to name a few (Jansson and Persson, 1982; Myrold and Bottomley, 2008). This might suggest soil classification could be used to estimate fertilizer N requirements for sugar beet production, but after several investigations, the overwhelming conclusion was that soil classification based on soil texture and soil survey series was ineffective as a predictor of fertilizer N needs (Webster et al., 1977). Rather, estimates of residual soil N and the amount of N mineralized during the growing season were better predictors of fertilizer N needs. Soil N mineralization is almost impossible to predict ahead of time because of all the variables influencing mineralization.

Recently, the American Crystal grower data base from two production years were subjected to geostatistical analysis based on total N used (residual soil N plus fertilizer N) in sugar beet production (Sims, 2009). There was a clear geospatial relationship with total N used by the sugar beet producers. There were several areas where total N use was higher than current N recommendations (Lamb et al, 2001), but the largest single area started in northwest Polk and ran along western Marshall and Kittson Counties in Minnesota. Though not subjected to geospatial analysis, this same area tends to have soils with heavier or finer textures than areas showing lower total N use.

This same area also tends to have some of the lower sugar beet root yields, but higher sugar beet root quality than other American Crystal growing areas (Personal communications with Tyler Grove, American Crystal Fieldman). Why does this area seem to require greater total N use without the typical corresponding increase in root yield and reduction in root quality? Sims (2010) found that sugar beet root yields tended to increase only slightly, but continuously, over a range of 0 to 240 lbs. applied N A^{-1}. At the same time, sugar beet root quality increased up to about 90 lbs. applied N A^{-1} then leveled off at higher N rates (did not decline). Nitrate in the most recently mature leaf petiole collected in mid-July was low regardless of the fertilizer N rate (Sims, 2010) suggesting either the N was not available or the sugar beet plant was not able to gain access to it. The lack of N in the plant would also explain why root yields did not increase dramatically and quality did not decline. Visual observations suggests the dark soil layer, signifying organic matter, in these soils is not very deep. Combined with higher amounts of fine textured clay in these soils, is it possible that N mineralization is less in these soils? If that is the case, then higher rates of total N or fertilizer N would be required to meet sugar beet N demands. While this may explain why growers in the area use more N, it does not explain why the higher rates of applied N are either unavailable to the sugar beet plant or the sugar beet plant unable to gain access to it. In 2010, a follow up trial examined the possibility of increasing N available to the plant by sidedressing in a band near the plant row (Sims, unpublished data). Petiole samples taken about one week after the sidedress application revealed that plants sidedressed with 60 lbs. N A^{-1} (90 lbs. N applied preplant for a total of 150 lbs. N A^{-1}) had nitrate levels as higher or higher than that of 210 lbs. of fall applied N. This suggested the sidedress band of N near the seed row was accessed relatively quickly by the sugar beet plant. Ultimately, this sidedress treatment resulted in root yields similar to those of the high rate of fall applied N with no detrimental effects on root quality. These results suggest that a more intense N management strategy may improve fertilizer N utilization efficiency in sugar beets grown in these areas where higher N use is typical.

Objectives:

1. Determine if fertilizer N placement and timing can improve fertilizer N availability and utilization in sugar beet production on finer textured soils in the RRV.

Materials and Methods:

Two trials were established in the fall of 2011. One trial was established 10 miles north and 3 miles west of Alvarado, Minnesota in a grower-cooperator field where excess N is required for optimum sugar beet production. A second trial was established on NWROC property 2miles north and 2 miles west of Crookston, Minnesota. Both trials contained the same treatments, but the N rates were different.

The experimental design in both trials is a split-plot randomized complete block with four replications. Whole plot treatments were N rates. Nitrogen rates at the Alvarado site were 90, 120, 150, and 180 lbs. N A^{-1} plus soil residual N. At the Crookston site the N rates were 60, 90, 120, and150 lbs. N A^{-1}. Both experiments contained two 0 N controls in each replication. Split-plot treatments consisted of fertilizer placement and timing:

1. Fall broadcast (100% of N fertilizer)
2. Fall banded below where seed row will be placed in the spring (100% of the N fertilizer)
3. Combination Fall application (50% N fertilizer broadcast and 50% N fertilizer banded)
4. Fall broadcast plus sidedress (varied with N rate; sidedress N is either 30 or 60 lbs. N A^{-1})
5. Fall band plus sidedress (varied with N rate; sidedress N is either 30 or 60 lbs. N A^{-1})

Wheel tracks in the banded treatments were marked to identify the placement of the tractor tires at planting this next spring in order to place the planted seed row directly over, or as close as possible, over the fertilizer band.

Immediately after experimental plots were established, soil cores to a 4 ft depth. were taken from each alley between replications and will be analyzed for residual nitrate-N .Sugar beet will be planted in 2012 and root yield and quality will be monitored.

Results:

The 2011-2012 proposal requested funding to establish the trial north of Alvarado. No data has been collected at this point, but this area experienced very disappointing sugar beet production in 2011. It is thought, N loss through denitrification may be the cause. The Crookston site was established as a comparison in an area where high N requirements and N loss does not seem to be an issue. In addition, the Crookston site can serve as a display site in the 2012 summer field tours at NWROC.