TIMING NITROGEN APPLICATIONS FOR SUGAR PRODUCTION AND INCREASED NITROGEN EFFICIENCY

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Sugarbeet producers in southern Idaho are often faced with decisions regarding nitrogen and its effective management within their cropping systems. This becomes especially critical when growers consider nutrient management, water quality and increased attention farming practices have on controlling groundwater pollution. Nitrogen uptake by plants is in two forms; NO$_3^-$ and NH$_4^+$ ammonia. These two are the only forms nitrogen can be utilized by the growing plants. They have different chemical properties and consideration should be made in their utilization. The nitrate form has a minus sign which is the same sign or charge the surrounding soil particles have. Because it has the same charge nitrate is more mobile and has a tendency to leach out of the system sooner than the NH$_4^+$ or ammonia form. The ammonia form has a plus charge and tends to stay tied to the soil particles longer. Nitrogen management should be concerned with the four following factors: 1) source of nitrogen, 2) rate of application, 3) placement, and 4) time of application. As we relate forms of nitrogen to the mobility and soil solution we can see differences. Those differences are quite striking and relate to the mobility of nitrate out of the rooting system towards groundwater. Organic nitrogen, or a form of nitrogen commonly referred to as manures, has the least mobility. The ammonia form of nitrogen NH$_4^+$ has essentially the same mobility as the manure, only slightly higher. Urea is next in potential mobility and this form of nitrogen is fairly mobile. The highest mobility of all nitrogen compounds are fertilizers in the NO$_3^-$ form or nitrate. Nitrate has the greatest potential for leaching out of the soil system.

Any management decisions related to fertilizer should be based upon soil testing. Remember the soil test numbers are index or empirical numbers. Empirical means values which are subject to change as research information becomes available. Researchers are continually doing work to provide growers in southern Idaho with better soil test numbers related to critical nutrient needs within their cropping systems.

Soil test numbers should also be related to plant requirements. For example requirements of nitrate utilization by sugarbeets are indicated by NO$_3^-$ petiole levels. These levels relate to both yield and percent sugar increases. Soil test results are compiled for nitrogen through a simple mathematical process. Farmers are recommended to take soil samples at 0-12 inches and also a 12-24 inch sample. Add those two values from the separate soil samples and multiply that value times four. The value you have would be converted from ppm (the soil index number) to a lb/A value. Utilize 4 because there are approximately 4 million pounds per acre foot of soil. We would then relate the soil test nitrogen level in ppm to the yield goal for sugarbeet growers. For example if the soil test number was 30 and yield goal was 28 T/A of sugarbeets we would want to apply approximately 120 lb/A of nitrogen. Keep in mind that following a grain crop apply approximately 15 pounds of nitrogen for every ton of straw returned back into the system.

To understand and to evaluate incremental applications of nitrogen a study was conducted by Frank Anderson, University of Nebraska. He had 17 treatments that composed or compiled various increments of nitrogen being applied during the growing season. These rates related to approximately 60, 90, 120, 180, and 240 Kg/ha of nitrogen being applied. As a reference value, Kg/ha divided by 1.12 is equal to lb/A of nitrogen applied. As another reference, 180 Kg/ha nitrogen is essentially equal to 160 lb/A of nitrogen. His experiment was conducted over a three year period and

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evaluated root yield, percent purity of sugar, and total sucrose or sugar production. In determining the values for the root yield there is relationship to increasing root yields with increasing nitrogen rate across all nitrogen application rates. Percent purity was also evaluated. There was a linear decrease in percent purity related to nitrogen. As the nitrogen increased there was a direct decrease in percent purity of sugar. The same type of relationship appeared for total sugar percentage produced. As the amount of nitrogen was increased the total sugar concentration was decreased all three years. Timing of the nitrogen as well as rates were evaluated for root yield.

The evaluation included 60, 90, 120, 180 and 240 Kg/ha of nitrogen being applied. The 60 Kg/ha was broken into either a single dosage or split twice with 230 Kg/ha increments. The 90 Kg/ha was similar; either applied in one application or split into 30 Kg/ha increments. The 120, 180, and 240 were similar types of treatments. There was no significant difference in incrementing either the 60, 90, 180 or 240 Kg/ha nitrogen application rates. However, when he evaluated the 120 Kg/ha application there was a significant impact on root yields when increments of 30 Kg/ha were compared to the single application of 60 Kg/ha. Sucrose yield in T/ha was also evaluated across the same nitrogen application rates. Again, there is no significant advantage of splitting the nitrogen for the 60, 90, 120, or 240 Kg/ha nitrogen applications. However, when the recommended rates of nitrogen were applied for the 180 Kg/ha there was a significant impact on splitting the nitrogen application rate. When the 180 Kg/ha application rate was split out in six 20 Kg/ha increments it was more advantageous than either three 60 Kg/ha rates or two 90 Kg/ha rates.

Through a linear relationship the maximum sucrose yield occurred with a nitrogen rate equaling 160 lb/A and was in addition to the soil nitrate nitrogen level of 34.4 lb/A. We would, therefore, recommend that splitting nitrogen increases efficiency of the nitrogen fertilizer. Sucrose responds negatively to increased nitrogen application. In other words, as the general nitrogen application rates increase the overall sucrose concentration decreases. This was also shown in work done by Halverson et al, 1978, where he evaluated a recovered sucrose against overall root yield in T/A. As Halverson increased the soil plus the fertilizer nitrogen there was a significant reduction in recoverable sugar and also an increase in total root yield. Therefore, we can say that root yield and sugar increased with increments of nitrogen at the 180 Kg/ha rate even though the overall sucrose concentration decreased with an overall nitrogen application rate. Halverson also indicated that as the soil plus the nitrogen rates increased there was also an increase in ppm of impurities as amino-nitrogen. Recoverable sucrose increased up to approximately 180 Kg/ha of nitrogen and a drastic reduction in recoverable sugars occurred after nitrogen exceeded the 180 Kg/ha rate.

In final summary we can say that petiole nitrogen analysis also indicated that a nitrate nitrogen concentration of 2,000 ppm on day 245 of Frank Anderson's work maximized sucrose yields. It can be further stated that incrementing nitrogen rates had no effect on topgrowth. The linear response of tops to over-application of nitrogen where excess supplies of soil nitrogen resulted in low sucrose concentration. While topgrowth is active the photosynthesize is used vegetatively instead of being stored as root sucrose. Large top weights are not needed for efficient sucrose production. Once topgrowth is adequate to intercept the instant light, further production of topgrowth is inefficient in terms of obtaining optimum sucrose yields.

Incrementing fertilizer nitrogen to supply only enough for immediate plant needs as compared to the larger earlier season single applications was studied each year of Dr. Anderson's work. Maximum sucrose yield occurred at an average nitrogen rate of 160 lb/A of nitrogen with approximately 35 lb/A of soil nitrate nitrogen at planting.
Incrementing the 160 pounds of nitrogen into six portions produced significantly more sucrose than did incrementation into three 50 lb/A portions or two 80 lb/A portions. At rates lower than 160 lb/A of nitrogen the trend favored incrementing nitrogen into the smallest portions.

Yield and sucrose concentrations increased with incrementing nitrogen applications. The affect on roots was most obvious at the 120 kilogram of nitrogen per hectare rate, but the trends favored incrementing at other rates also. A smaller affect was observed on sucrose concentrations. Petiole analysis was also analyzed and indicated that maximum sucrose production occurred if nitrate nitrogen concentrations were at 2,000 ppm on day 245. Delaying application of the total nitrogen supply by incrementing applications favored root development and sucrose production but not because of any diversion of energy from topgrowth to sucrose storage.