SF-714 (Revised)

Fertilizing Sugarbeet

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Sugarbeet growers in this region

are paid based on the tons of recoverable sucrose that is extracted from their crop. Sugarbeet profitability therefore depends on producing a high tonnage crop that is high in sucrose content. Nitrogen management is an important key to accomplishing this goal. Nitrogen deficiency leads to poor leaf canopies, premature yellowing and low tonnage yields. Grower payments are based on tons of sucrose delivered to the processor less impurities, such as nitrate grade and amino-N content. Excess nitrogen results in reduced sucrose content and higher impurity levels ***(Table 1)***. Good nitrogen management is necessary not only in the year in which beets are grown, but also in the rest of the rotation, so that soil N levels are not excessive going into the beet year.

Table 1. Reduction in sugar content of sugarbeet with increasing N availability. *(Adapted from Smith, 1984.)*

N, 0-24 inch depth + added N	Sugar content	Recoverable sugar per acre
lb/a	%	lb/a
100	14.4	6040
150	13.2	5600
200	13.1	5440
300	12.6	5110

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New nitrogen recommendations

Nitrogen, phosphorus and potassium recommendations for sugarbeets are no longer based on yield goal ***(Table 2)***. With recommended N rates and favorable growing conditions, additional N mineralization will support a high-yielding, high-sugar crop. Over-fertilization will result in poor recoverable sugar yields in years which do not support higher tonnage yields.

The supplemental N recommendation is based on four-foot soil samples, broken down into at least the zero to two-foot and two to four-foot depths. The zero- to six-inch depth is separated out if P, K and other nutrient analysis is desired. Sampling conducted immediately following small grain harvest is acceptable. Sampling prior to initial tillage would usually result in a better zero to six-inch core than following tillage.

Regardless of the amount of residual soil N below two feet, a minimum of 65 lb. N/acre is required in the zero to two-foot depth to maximize early growth, yield and quality. If only a zero to two-foot depth sample is taken due to excessive soil wetness or sandy soil strata that plugs soil tubes, the N recommendation is 100 lb. N/acre less nitrate-N in the zero to two-foot core. If the soil sample is taken to four feet, then the N recommendation is 130 lb. N. The four-foot depth would be expected to be more precise than taking a zero to two-foot core and estimating that 30 lb. N/acre. resides in the next two feet. The deeper depth is encouraged wherever possible.

Other N guidelines

These N recommendations were developed through experimental testing at both the small plot and field level. Any normal N mineralization from organic matter is already factored into the recommendations.

Previous manure applications will decrease the amount of N required as supplemental fertilizer. Determine the N content of the manure and an estimate of the release from University of Minnesota or NDSU circulars. Given the unpredictability of manure N release, it is best if manure were not applied immediately prior to sugarbeet production.

Fall-application of N is effective except on sandy soils (sandy loam or lighter), soils near rivers and streams which frequently experience spring flooding and high water table soils. Application of fall anhydrous should be delayed until at least Oct. 1 in the Red River Valley, and then only if soil temperature falls to 50 degrees, measured at the four-inch depth between 6 a.m. and 8 a.m. This delay does not

Table 2. Nitrogen, phosphate and potassium recommendations for sugarbeets.

Soil N plus fertilizer N needed*		Phosphorus					Potassium			
		VL	L	M	H	VH	VL	L	M	H
		ppm					ppm			
lb/a 2 feet 100	†Bray-1	0-5	6-10	11-15	16-20	21+	0-40	41-80	81-120	121+
	Olsen	0-3	4-7	8-11	12-15	16+				
lb/a 4 feet 130**		P_2O_5, lb/a					K_2O, lb/a			
		80	55	35	10	0	110	80	50	0

* Subtract the amount of NO_3-N in the top 2 feet of soil or top 4 feet of soil from these figures to determine the amount of N fertilizer to apply.

** **NOTE:** Before making available in excess of 120 lb of soil plus fertilizer N to your beet crop, consult with your agriculturalist, extension agent, or university specialist.

† Use the Olsen P test on soils with pH greater than 7.

guarantee that no nitrification will occur, but it greatly reduces the risk. Application of N too early greatly increases the risk of nitrate formation before winter, which increases early spring losses of N due to leaching, runoff and denitrification.

Subsurface-banded application of urea should be delayed at least a week following favorable conditions for anhydrous application, and broadcast and incorporated urea applications should be delayed two weeks following acceptable anhydrous application conditions. Applications can be split on acceptable soils between fall and spring. Sidedress N application is not recommended.

Previous crop N credits

If sugarbeet follows soybeans or dry edible beans, a previous crop credit of 40 lb./acre should be applied against the N recommendations from soil tests. For example, if the soil test following soybean suggests 80 lb. N/acre of supplemental N, then the N recommendation should be 80 lb. N/acre - 40 lb. N/acre = 40 lb. N/acre. The recommendation that the previous crop credit for soybeans be based on soybean yield has already been discarded in Minnesota, Wisconsin and Iowa where intensive examination of this practice has been conducted.

Site-specific N considerations

Use of imagery to direct previous crop credits from sugarbeets to subsequent rotational crops

The fact that sugarbeet tops can contribute N to subsequent crops was first shown by the French in 1967, then by a California study in the 1980s. It was not until the work of Moraghan and Smith in the mid-1990s that the concept became a practical consideration for general adoption. Sugarbeet canopies often vary from dark green to yellow within a field at harvest. The canopy color is strongly related to the N content, which increases from yellow to green canopies ***(Figure 1)***.

Recommendations for a previous crop credit following sugarbeets are:

- yellow tops at harvest, 0 credit,
- yellow-green tops, 30 lb. N credit,
- green tops, 80 lb. N credit.

Failure to account for excessive sugarbeet top N can contribute to over-fertilization of subsequent crops in the rotation, resulting in a buildup of deep soil N. Reduction in sugarbeet profitability can result, as shown by Moraghan in Walsh County, N.D., in the 1980s and Franzen, Reitmeier, Hapka, Cattanach, Giles and others in Pembina County, N.D., in the late 1990s.

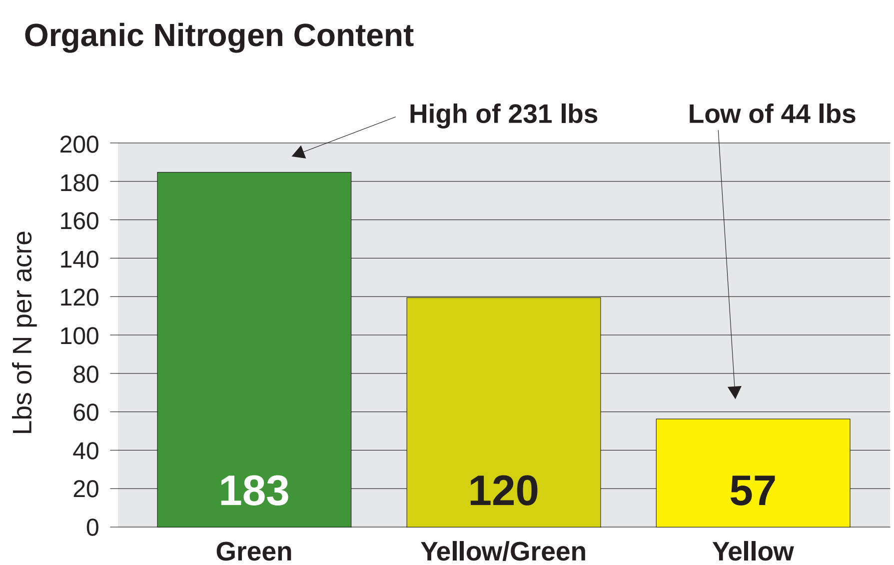


Figure 1. Relationship of sugarbeet canopy cover and lbs N/acre in the sugarbeet tops. *(Adapted from Moraghan, 1994.)*

Other crops may also be affected through disregard for N in sugarbeet tops ***(Figure 2)***. Imagery can be used to delineate areas which differ in canopy color.

Use of imagery can also be used to reduce the need to soil sample some parts of sugarbeet fields, since areas with yellow tops will always test 20 lb. N/acre or lower in the zero to four-foot depth. Additionally, satellite imagery is used as a tool to apply N credits following beets based on the yellow, yellow-green and green top concept ***(Figure 3)***.

Sampling to direct variable N applications prior to sugarbeets

Site-specific soil sampling can increase the ability to maximize sugarbeet yield and quality through more precise N application. Grid soil sampling, with grid size typically of four to five acres in size was first used in this region in 1994. Subsequent research has shown that in many fields, a zone approach would more reliably represent N fertility patterns. A zone approach assumes that fertility patterns exist for a logical reason, and are not a result of random chance. Thirty-eight site years of data throughout North Dakota, with several sites located within sugarbeet growing areas within the Red River Valley are the basis for these conclusions. A knowledgeable consultant or sugarbeet industry field person can help growers determine which sampling strategy might work best in a field.

Several methods could be used to delineate N management zones. Satellite images of a beet field are useful not only for the crop following beets, but the next beet crop also ***(Figure 4)***.

Figure 2. Affect of not applying N credits to wheat (left) and applying N credits (right). Failure to apply N credits from previous year sugarbeet tops resulted in lodging to over-fertilized wheat.

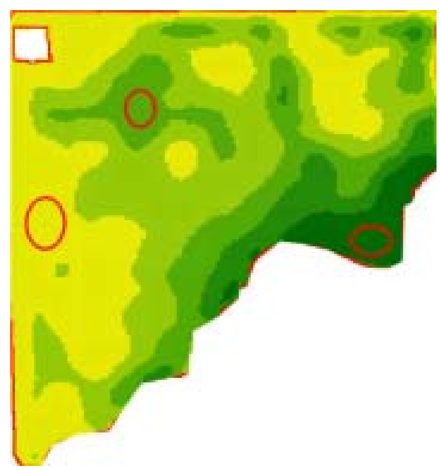


Figure 4. A previous beet crop image may be used as a zone delineation tool for crops grown in the field two to four years into the future, including the next sugarbeet crop. Nitrogen management zone boundaries change little between years. Soil sampling within each zone is required after the subsequent crop to imagery to determine the N recommendation within each zone. Other delineation may be combined with imagery to further refine zone boundaries.

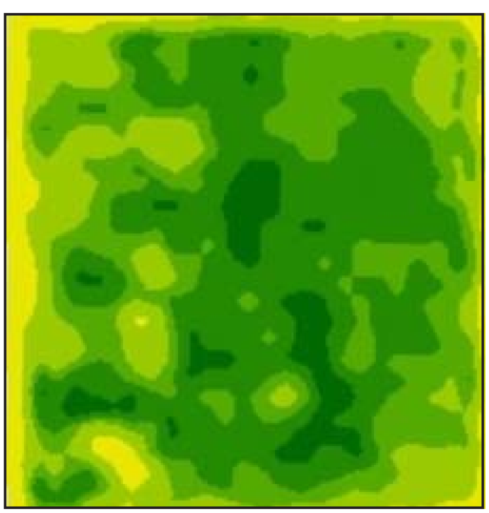


Figure 3. Satellite image showing green, yellow green and yellow areas, based on imagery biomass estimates.

This is possible because N management zones tend to be stable over years. Zone delineation can also be enhanced by including data such as topography (even microtopography is important) ***(Figure 5),*** soil EC (electrical conductivity) sensor measurements ***(Figure 6)***, aerial photography ***(Figure 7)*** and yield monitor data ***(Figure 8)***. Topography in the Valley should be measured with RTK (real-time kinetic) GPS, as compared to elevation obtained from the GPS normally used for fertilizer application or yield monitors. The error in the vertical is greater than the error laterally in GPS receivers. Elevation measurements in the Valley should be accurate to within an inch. Variations of only a few inches are significant enough to make a difference in soil series delineation and residual N differences from surface/subsurface nitrate movement.

None of the zone delineation methods can predict residual nitrate-N levels by themselves, but the zones of uniformity that their delineation represents can be used to direct soil sampling. Nitrogen fertilization by zone has recently been shown to be a profitable sampling strategy for sugarbeet growers, compared to composite and grid soil sampling ***(Figure 9)***.

To sample within a zone, the sampler should take about 10 cores within each zone, avoiding the edges of the zone. These cores are then composited to represent the nutrient status within the zone.

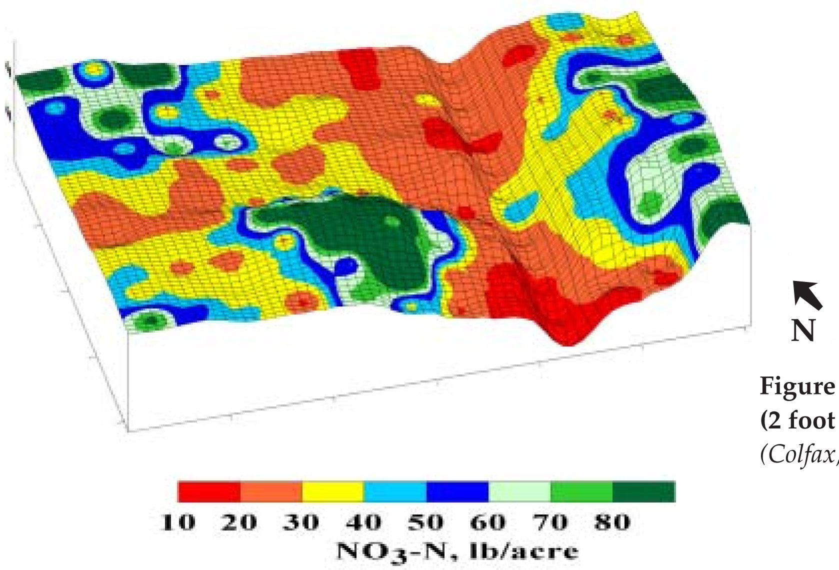
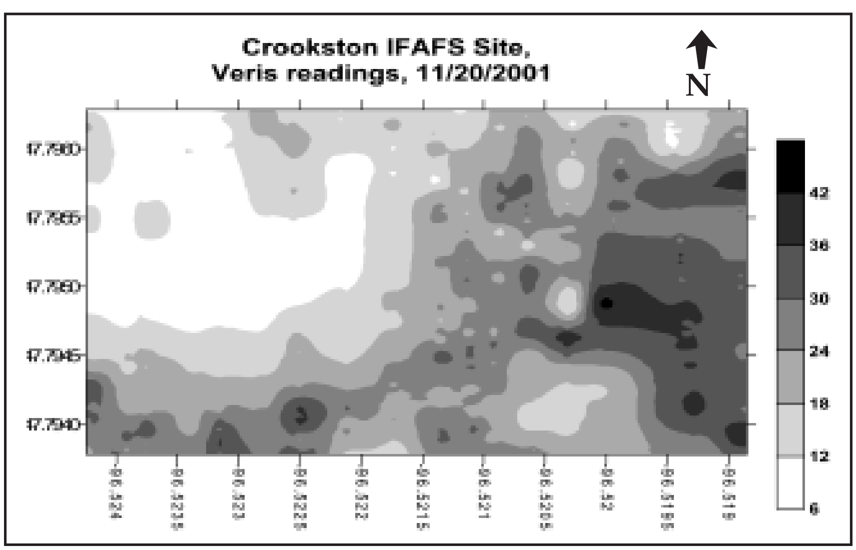


Figure 5. Soil nitrate overlaying topography (2 foot elevation difference within 40 acre field).
(Colfax, 1995.)

Figure 6. Electrical conductivity sensor and readings from a field east of Crookston.



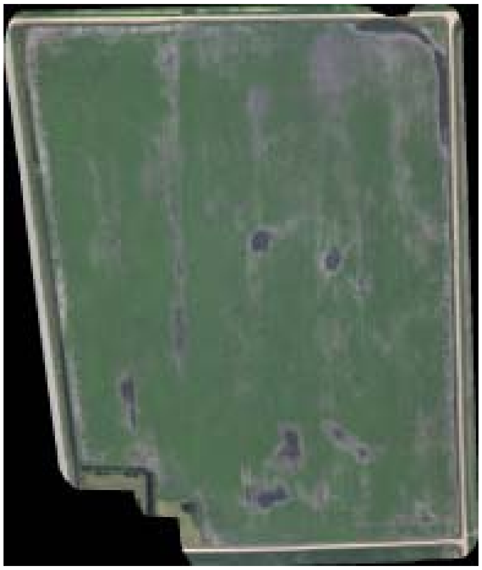


Figure 7. Aerial photo showing fine details available from a nadir Ektochrome photo, sugarbeets, mid June photograph. Note the fine details of drainage features, field traffic and variations in greenness.

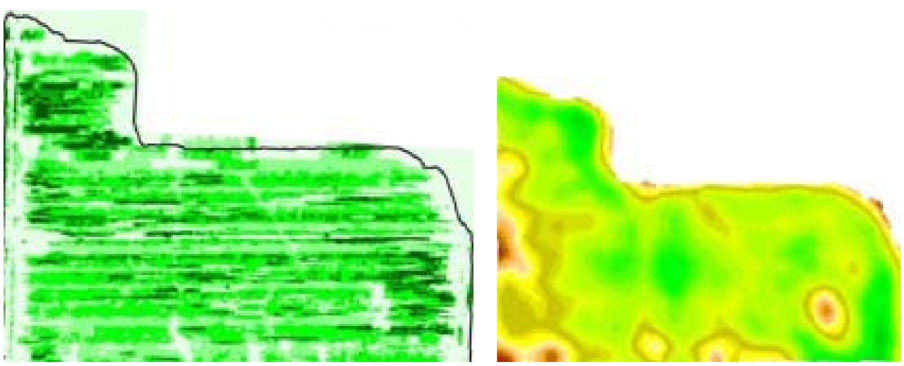


Figure 8. Sugarbeet yield map (left) compared with satellite image of field (right).

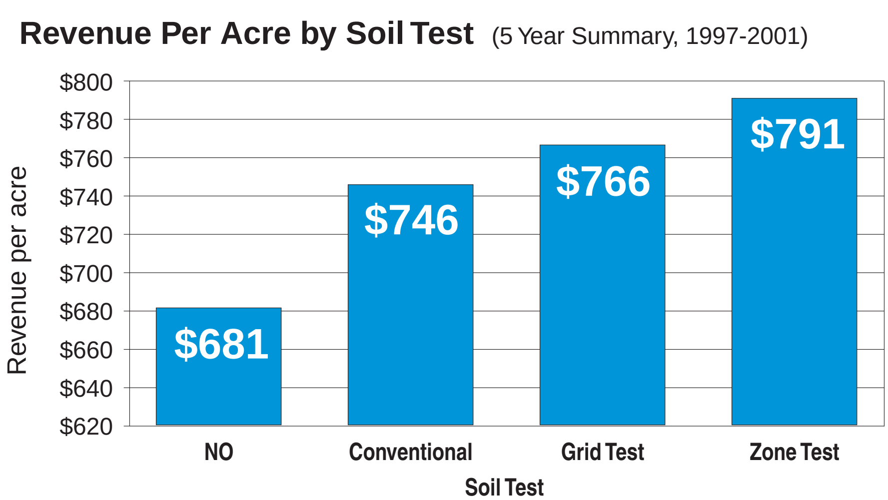


Figure 9. Gross revenue per acre of sugarbeets from different soil sampling approaches to direct N applications. From annual sugarbeet survey. *(American Crystal data, 2002.)*

Phosphorus (P)

The phosphorus recommendations in ***Table 2*** represent broadcast P rates which will increase soil test levels over time if soil test is in the very low to medium ranges. Recent research at Crookston has shown that two to three gallons of seed-placed 10-34-0 gives equivalent sugarbeet yields as those achieved through recommended broadcast P rates. However, most crops in a sugarbeet rotation, including barley, wheat, corn, soybeans and potatoes, perform best when soil test levels are at least medium. To help maintain soil test levels, more frequent soil testing for P is recommended, so that adequate P rates are applied to other rotational crops.

Phosphorus guidelines in ***Table 3*** will aid in decisions regarding whether to broadcast or band fertilizer.

The following are guidelines for sugarbeet fertilization with P:

> *Sugarbeet seed and seedlings are sensitive to fertilizer salts and free ammonia. Germination and emergence can be reduced if N and K fertilizers are placed in direct contact with the seed at excessive rates. When using a seed-placed starter, 10-34-0 or MAP (monoammonium phosphate, 10-50-0, 11-48-0, 11-52-0 etc.) are preferred products. Avoid application of over 5 lb. N + K_2O with the seed.*

Fallow syndrome

Sugarbeets do not support mycorrhizae, which are a soil fungi which live in a symbiotic relationship with most plants, except those from the lambsquarters and mustard families. Mycorrhizae are particularly important in mobilizing P through their extensive system of hyphae (pseudo-roots). Most of our crops appear to be able to compensate for the reduced soil mycorrhizae activity following sugarbeets except for corn ***(Figure 10)***. If corn follows sugarbeets, it will be necessary to increase P rates significantly to offset the reduction in soil mycorrhizal activity. Rates of 2 X 2 starter application of 40 lb. P_2O_5 may be needed to achieve comparable yields as corn grown following mycorrhizae supportive crops. Increased rates of broadcast P are generally less effective.

Figure 10. Fallow syndrome symptoms on corn following sugarbeet, near Rothsay, Minn., 1997. Corn on the left follows sugarbeet. Corn on the right, same variety, planted same day on soybean ground.

Table 3. Guidelines for sugarbeet fertilization with P.

Soil Test Level		
Olsen	**Bray**	**Recommendations**
ppm	ppm	
12+	11+	Apply no P fertilizer.
<12	<11	If you fall apply P at recommended rate, no additional P is needed.
8-11	6-10	Use either 3 gpa 10-34-0 seed-placed or recommended broadcast P rate.
<8	<6	Use 3 gpa 10-34-0 seed-placed and 40 lb/a P_2O_5 broadcast. (3 gpa 10-34-0 produces yields equal to recommended broadcast P rates).

Potassium (K)

Low soil K is less an overall problem than N or P, but deficiencies can occur in sandy soils, especially in the beach and inter-beach areas of the Valley. Sandy soils do not have the cation exchange capacity for buildup and maintenance of adequate soil K levels, making annual applications necessary. Broadcast applications can be used, but banded applications are also effective if the fertilizer and seed bands are separated. Because of the sensitivity of seed to fertilizer, low rates of seed-placed K are not recommended.

Micronutrients and secondary nutrients

Considerable research has been conducted on the application of micronutrients to sugarbeet in this region. Responses to zinc, manganese, copper, sulfur, iron and boron have not been demonstrated. If questions regarding these nutrients arise, use a small check strip to test suspicions.

Calcium deficiency has been observed in sugarbeet in the region, but it has been associated with weather conditions which result in a physiological deficiency, not a deficiency which could have been averted through the application of calcium amendments. When transpiration water is not moving through the plant, calcium cannot move to where it is needed sometimes and deficiency symptoms develop. This is a relatively rare event.

Sulfur deficiency is possible on sandy soils highly susceptible to leaching. The deficiency would be more common early in the season, before more sulfur enriched subsoils were explored by roots. Use of a sulfate or thiosulfate source of sulfur would be more efficient and more available early in the season than elemental sulfur.

Lime and soil pH

Sugarbeets are grown in soils ranging in pH from 5.2 to 8.5. There is recent evidence that soil pH should be at least 6.5 for good sugarbeet production. The rate of limestone needed to correct a low pH problem is dependent on the source of lime, the fineness and its effective neutralizing power. Guidelines are presented in the *North Dakota Soil and Fertilizer Handbook, 2003, EB-65*. It is not recommended to decrease high pH levels. Although theoretically possible to do so, it is not practical to perform such an exercise. Most sugarbeet varieties perform well at high pH levels.

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