SF714 (Revised)

Fertilizing Sugar Beet in North Dakota

Photo: iStock.com

David W. Franzen, NDSU Extension Soil Specialist

Sugar beet growers in this region are paid based on the tons of recoverable sucrose that is extracted from their crop. Therefore, sugar beet profitability depends on producing a high-tonnage crop that is high in sucrose percentage.

Nitrogen (N) management is an important key to accomplishing this goal. Nitrogen deficiency leads to poor leaf canopies, premature yellowing and low tonnage yield. Grower payments are based on tons of sucrose delivered to the processor less impurities, such as nitrate grade, amino-N content and excess potassium. Excessive nitrogen results in reduced sucrose percentage and higher nitrate grade and amino-N impurities (Table 1).

Good nitrogen management is necessary not only in the year in which sugar beets are grown, but also in the rest of the rotation, so that soil N values are not excessive going into the sugar beet growing year.

Table 1. Reduction in sugar content of sugar beet with increasing N availability. (Adapted from Smith, 1984). Studies conducted recently on modern sugar beet cultivars support this relationship.

Nitrate-N, 0-2 foot depth plus fertilizer N	Sugar content	Recoverable sucrose
lb/a	%	lb/acre
100	14.4	6,040
150	13.2	5,600
200	13.1	5,440
300	12.6	5,110

Nitrogen

Nitrogen (N), as well as phosphorus (P) and potassium (K) recommendations are not based on yield goals. Since these recommendations were published in 2003, sugar beet yields in certain fields have exceeded 30 tons/acre, and some fields have exceeded 40 tons/acre using these N recommendations.

Recent studies have re-examined the N recommendations using modern cultivars and farming methods and found that the recommended rates are sufficient for high yield and high sugar concentration.

Historically, soil sampling has been recommended to 4 feet in depth; however, in fields where sugar beet previously has been grown and sugar beet quality is high, the chance of high nitrate at depths below 2 feet is low. Therefore, except in fields new to sugar beet or in fields with a recent history of low sugar beet sucrose concentration, soil sampling depth can be 2 feet in depth instead of the previously recommended 4-foot depth.

Soil sampling may be conducted immediately following small-grain harvest. If taking a 4-foot-deep core, and the 0- to 2-foot nitrate-N is less than 65 pounds of N/acre, enough N should be applied regardless of the total nitrate-N value in the entire depth to achieve a 65 pounds of N/acre value.

NDSU EXTENSION SERVICE
North Dakota State University, Fargo, North Dakota
Revised January 2018

Table 2. Nitrogen, phosphorus and potassium recommendations for sugar beet.

Soil N plus supplemental N	Olsen Phosphorus 0-6 inch core, ppm					Potassium soil test, 0-6 inch core, ppm				
	VL	L	M	H	VH	VL	L	M*	H**	VH
100 lb N/2 feet	0-3	4-7	8-11	12-15	16+	0-40	41-80	81-120	121-150	150+
	Broadcast rate P_2O_5, lb/a					K_2O, lb/a				
130 lb N/4 feet	80	55	35	10	0	120	90/120†	50/90	0/60	0

* 120 parts per million (ppm) is critical K value for soils with smectite/illite ratio 3.5 or less (Figure 1).

** 150 ppm is the critical K value for soils with a smectite-to-illite ratio greater than 3.5.

† In a divided K rate, the small number is for soils with a smectite-to-illite ratio of 3.5 or less and, the larger number is the rate for soils with a smectite-to-illite ratio greater than 3.5.

The N recommendations in Table 2 were developed as the result of field studies at the small-plot and field scales. Any organic matter N release from mineralization already is factored into the recommendation. Previous manure applications will decrease the amount of N required as supplemental fertilizer. Determine the N content of manure and an estimate of release from University of Minnesota or NDSU publications.

Given the unpredictability of manure N release, do not apply manure immediately prior to sugar beet production. If manure was applied in the sugar beet production year, a strip of enhanced N rate should be applied as a comparison should N release be less than anticipated due to excessive rainfall or drought.

N recommendations also should be adjusted based on previous crop credits, shown in Table 3. Seeding sugar beet after alfalfa or sweet clover is not recommended due to the uncertainty of N release from these residues.

Fall N application can be effective, except on sandy loam or coarser-textured soils, soils near river flood plains and high-water table soils.

Application of fall anhydrous ammonia should be delayed until Oct. 1 at the earliest, and then only when the soil temperature measured at the 4-inch depth between 6 and 8 a.m. reaches 50 F. This recommendation is not a 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 the early spring losses of N due to leaching, runoff and denitrification.

Subsurface-banded urea application should be delayed at least a week following favorable conditions for anhydrous application, and broadcast and incorporated urea application should be delayed two weeks following the acceptable anhydrous ammonia application date. Applications can be split on acceptable soils between fall and spring.

Side-dress N application has become more common in this sugar beet production area, mostly for use in corn production. In soils with little risk of in-season N loss, side-dress is a greater risk to production than a preplant N application. However, side-dress N studies on high-clay soils with high spring rainfall found that when the N was applied at V6, it resulted in higher sugar beet tonnage and sugar production.

Sugar beet growth and leaf color in a strip, when the planned side-dress rate of N is applied in a strip with the preplant fertilizer, can be an indicator of whether side-dress N is required. Yellowing of the sugar beet canopy during the growing season may be related to N, but it also could be related to the incidence/severity of disease, K deficiency, S deficiency, or excessively wet or dry conditions. The N-enhanced strip will help a grower determine in-season N status because the strip also is subjected to a similar environment as the rest of the field.

Table 3. Previous crop credit from annual legume crops to be subtracted from sugar beet N recommendations.

Previous crop	Credit
Soybean	40 lb. N/acre
Dry edible bean	40 lb. N/acre
Other grain legume crops (field pea, lentil, chickpea, faba bean, lupin)	40 lb. N/acre
Harvested sweet clover	40 lb. N/acre
Alfalfa that was harvested and unharvested sweet clover*:	
>5 plants/sq. ft.	150 lb. N/acre
3-4 plants/sq. ft.	100 lb. N/acre
1-2 plants/sq. ft.	50 lb. N/acre
<1 plant /sq. ft.	0 lb. N/acre

Second-year N Credits

Half of the N credit indicated for the first year for sweet clover and alfalfa is recommended, but no N credit is recommended after the second year for other crops.

*** Seeding sugar beet following alfalfa or sweet clover is not recommended due to the uncertainty of N release from their residues.**

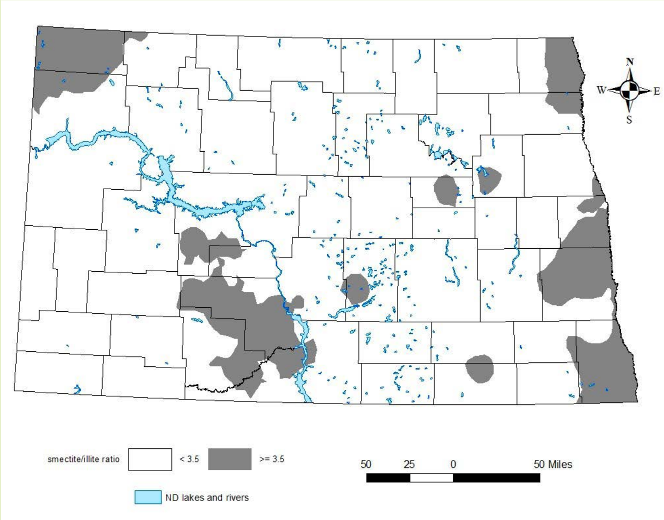

Figure 1. Smectite-to-illite clay ratio of soils in North Dakota, from sampling survey of fields, 2017.

Fertilizer N Forms

Most N sources are appropriate for use in sugar beet production. Spring urea rates should not exceed 100 pounds of N/acre or stand reductions are possible. Also, the use of poly-coated urea products, such as ESN (Agrium Ltd.) are discouraged because late release may reduce sugar concentration.

Site-specific N Considerations

Sugar beet growers have been leaders in site-specific nutrient application for more than 20 years. In 2016, 53.6 percent of American Crystal Sugar Co. sugar beet growers used site-specific nutrient application in their production. In addition, a sizable percentage of sugar beet grower acres were screened for possible site-specific N application using a composite soil test.

If the composite soil test was below a certain value, the probability of economic return from site-specific N application is low, so zone sampling and site-specific N application were not pursued. If the composite soil test was above that value, zone sampling was conducted, followed by site-specific N application. Sugar beet growers who utilized site-specific realized $48 per acre more than their neighbors who did not, averaged across the past 10 years.

Sugar beet leaf color also has been used to adjust N rates site-specifically for the subsequent N-requiring crop in the rotation, such as spring wheat. At harvest, green sugar beet leaf color will result in 80 pounds of N/acre released to the next crop; yellow-green sugar beet leaf color will release 30 pounds of N/acre and yellow leaves will release no N.

Soil sampling for site-specific nutrient application almost always is best using a zone sampling approach. This approach is detailed in two NDSU publications: “Developing Zone Soil Sampling Maps” (SF1176-2, www.ndsu.edu/fileadmin/soils/pdfs/SF-1176-2.pdf) and “Yield Mapping and Use of Yield Map Data” (SF1176-3, www.ndsu.edu/fileadmin/soils/pdfs/SF-1176-3.pdf).

A few consultants use a grid sample approach with a one-sample-per-acre density when exploring a new field, but this sampling density is expensive to perform regularly, and once a zone pattern is found, a dense soil sampling grid has little practical use. Exceptions would be heavily manured fields or fields subjected to high buildup P and K fertilizer. In these fields, the P and K values are mostly high and would be related to a 2.5-acre grid, but N soil test values still would be zone-related.

To sample within a zone, mix 10 to 20 soil cores thoroughly and subsample enough soil from the container to represent the zone adequately. Soil cores in high-clay soil fields might have to be dried and ground before subsampling due to the difficulty of representing the entire area from muddy or resistant soil cores.

Phosphorus

Broadcast P rates are provided in Table 2. However, the research from the University of Minnesota, Crookston, by Sims and Smith has transformed most P application to sugar beets. Where once high broadcast P rates were common for sugar beet, most sugar beet acres are treated with 3 gallons/acre of 10-34-0 liquid starter in furrow or an equivalent fertilizer product. Perhaps because sugar beet is nonmycorrhizae-supportive, the concentrated P in the starter band is highly efficient, compared with broadcast P application.

Table 4. Guidelines for sugar beet fertilization with P, considering the starter P option.

Olsen soil test P, ppm	Recommendations
12+	Apply no P fertilizer
12	Fall applied P, use recommended P broadcast rate, Table 2
8-11	Use either 3 gal/acre 10-34-0 or recommended P broadcast rate, Table 2
1-7	3 gal/acre 10-34-0 + 40 lb P_2O_5 broadcast

Fallow Syndrome for Subsequent Crops

Fallow syndrome is a condition experienced after black fallow or following a nonmycorrhizae-supporting crop. Sugar beet does not support mycorrhizae fungus, which is a symbiotic fungus that can infect most crop species in our region except those in the mustard family (canola) or the lambsquarter family (sugar beet).

Following sugar beet with highly mycorrhizae-dependent crops, especially flax, but more commonly corn, is ***not*** recommended. If sugar beet must be followed by corn, you need up to 90 pounds of P_2O_5 in a 2X2 band application at planting to overcome the deficiency. Fallow syndrome symptoms in corn resemble P deficiency, zinc deficiency or both, combined with stunted height and reduced vigor.

Potassium

Recent studies in corn in North Dakota have resulted in a change of K recommendations based on the ratio of two prominent soil clays: smectite and illite. The type of smectite in our soils has temporary K-retention properties. In dry summers, smectites tend to draw soil solution K into themselves, and when the soil is moist, they releases K. Illites tend to release K wet or dry.

Therefore, the critical value for K is increased for sugar beet, which is a K-responsive crop, to 150 ppm for higher-smectite ratio soils, while the critical K level of 120 ppm remains the same as previous recommendations for soils with greater illite content (Table 2). A map of smectite-to-illite ratios showing soils with a ratio greater or less than the critical 3.5 value appears in Figure 1.

Sulfur

Sulfur deficiency has been recorded in sugar beets in coarser-textured soils in North Dakota for at least 10 years. Sulfur continues to be a growing problem for corn and small grains in the state and region due to reduced atmospheric deposition, higher crop yield, higher moisture and tile drainage.

If S deficiency is suspected, soil sampling is a poor determination tool. Plant samples taken from a “good” area, compared with a “deficient,” area would be far more diagnostic. If S is found to be a problem, an application of 10 to 20 pounds of sulfate-S, followed by rainfall, corrects the issue.

Sulfur is not a fall-application fertilizer. The sulfur source should be a sulfate/thiosulfate form, with any thiosulfate not contacting the seed.

Micronutrients

The region has had no confirmed reports of responses to soil boron, manganese, zinc or copper in sugar beet. Yield responses have occurred due to iron (Fe) application, with the ortho-ortho-EDDHA fertilizer being of most consistent value. Most of these responses were on coarser-textured, high-pH soils, with seed or near-seed placement.

Good nitrogen management is necessary not only in the year in which sugar beets are grown, but also in the rest of the rotation, so that soil N values are not excessive going into the sugar beet growing year.