FERTILIZING SUGAR BEET IN THE SOUTHERN MINNESOTA BEET SUGAR COOPERATIVE GROWING AREA

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Fertility Needs of Sugar Beet

Southern Minnesota Beet Sugar Cooperative gives financial incentives for delivering higher quality sugar beet roots to the factory. This is determined by the concentration of sucrose and impurities in the root that need to be separated during the refining process.

Optimum sugar beet production in the Southern Minnesota Beet Sugar Cooperative growing area in Minnesota relies on a sound soil fertility program. A sound fertilizer program can enhance the quality of the sugar beet. The recommendations suggested in this publication for the supplemental application of nitrogen (N), phosphorus (P), and potassium (K) are based on thirty years of scientific research in the sugar beet growing areas of Minnesota and North Dakota.

Nitrogen

Nitrogen is the single most important nutrient for optimum sugar beet production. Nitrogen status of the plant affects early growth or time to full canopy closure and the quality of the sugar beet at harvest. Optimum nitrogen management promotes vigorous early season plant growth reducing the number of days to canopy closure which allows the sugar beet to utilize the sunlight's energy more efficiently to make sucrose. Excess N at or near the end of the growing season reduces sugar beet quality by reducing sucrose concentration and increasing impurity concentration. Research has indicated that the greatest sugar beet quality occurs when the plants undergo N deficiencies late in the growing season starting about six weeks prior to harvest. However, the development of severe N deficiencies too early in the growing season, while enhancing quality, will reduce sugar beet root yield. The Minnesota soils, where most of the sugar beets are grown, can mineralize sufficient N from their organic matter to reduce the severity of N deficiency later in the growing season. Therefore, a good fertility program needs only to provide N during the early and mid parts of the growing season.

Soil Testing For Nitrate

The amount of nitrogen fertilizer application to a sugar beet crop should be based on a total N recommendation minus the nitrate-N from a soil test. The time of year at which the sample is taken is important. A soil sample for soil nitrate-N should be taken when the soil temperature at six inches depth have consistently dropped below 50 degrees F. Earlier sampling times will result in an inaccurate soil test value, see Figure 1. The depth to which to take the required soil test depends on the previous history of nitrogen management. It is recommended that a soil sample to a depth of four feet be taken if little knowledge exists on levels of nitrate-N below two feet. The recommendation based on a sample taken to four feet is 100 pounds N per acre (Table 1). This recommendation includes

the amount of nitrate-N in the soil sample and the amount added as fertilizer. If for some reason you can only sample to a depth of two feet, then the recommendation is 80 pounds N per acre. In some cases where previous management and soil conditions occur that would cause a large amount of residual nitrate-N to be in the soil, a sample to a depth of six feet may be needed. In all cases, it is suggested that a minimum of 65 pounds N per acre in the zero to two foot depth should be present no matter how much nitrate-N occurs in the two to four foot depth. Research has indicated that the soil samples should be taken from areas of 20 acres in size or less that are similar in landscape, soil type, or previous management.

Nitrogen Sources

The summary of several research trials indicate all N sources will perform similarly if applied appropriately to minimize losses. For environmental and N loss concerns, fall applications of nitrate forms of fertilizers such as urea ammonium nitrate solution (UAN) or ammonium nitrate are strongly discouraged. Anhydrous ammonia and urea N sources can be used either as preplant applications in the spring or the previous fall after soil temperatures at the six inch depth fall below 50 degrees F.

Split Applications

Split applications of N fertilizer may be wise for sugar beets grown on sandy soils. The split applications should be scheduled so the last application is done before July 1 to minimize the possible reduction in root quality at harvest. Research conducted in the 1980's and 1990's on heavier textured soil indicate that split applications did not perform better than a preplant application and actually decreased root quality in recent trials conducted in the Red River Valley, Table 2.

Previous Crop and Rotation Management

The above recommendations must be modified based on crop rotation and previous input management. The soil nitrate test is not accurate in situations where the previous crop is a legume such as alfalfa or manure applications have been made. It is strongly recommended not to grow sugar beets following alfalfa or where manure has been applied the previous year because of the increase nitrogen mineralized from organic N sources during the growing season. Research with sugar beet growth following alfalfa and manure application indicates that while root yield was not affected, the use of nitrogen fertilizer reduced sucrose concentrations and recoverable sucrose yields.

If a grower must use manure in the rotation, then it must be managed to take credit for the nitrogen mineralization that occurs from the manure. For more information on manure management, consult University of Minnesota Extension publication AG-FO-03553, Manure Management in Minnesota. This publication discusses nitrogen credits from different types and application methods of manure. The grower also much recognize the variability in the rate of nitrogen mineralization from the manure.

In the past it has been recommended not to grow sugar beet after soybean but recent research in Southern Minnesota and Northwestern Minnesota indicate that if the diseases such as rhizotonia can be controlled, a good sugar beet crop can be grown. Research from the Southern Minnesota area, Table 3, indicates in two of three years growing sugar beet after corn

resulted in the least extractable sucrose per acre while sugar beet grown after spring wheat resulted in the greatest extractable sucrose. Intermediate results were found when growing sugar beet after soybean. The previous crop in this research did not affect the optimum N application.

Phosphorus

Phosphorus is used by the plant for energy compounds. Phosphorus has been documented to increase root yields in soils that are low in phosphorus while not affecting quality. Since phosphorus is immobile, recommendations are based on a soil sample from the surface 6 to 8 inches. The phosphorus soil test does not measure the chemical form utilized by the plant as is the case with the nitrate test. The P soil test is only an index that has been correlated to the crop response to P fertilizers in field trials.

The availability index (soil test) used for recommendations is dependent on the soil's pH. If the pH is less than 7.4, a Bray P1 soil test can be used. When the pH is 7.4 or greater, the Olsen P soil test should be used. At this time, the University of Minnesota and North Dakota State University do not support the Mehlich III soil test. The recommendations suggested in Table 1 are based on broadcast applications of P fertilizer.

P Fertilizer Placement

Recent research conducted in Northwest Minnesota indicates that the use of a starter placement (pop-up) of fertilizer phosphorus with the sugar beet seed is more efficient than a broadcast application. Phosphate application rates of 3 gallons of 10-34-0 (12 lbs phosphate per acre) placed on the seed at planting produced similar root yields as a broadcast application of 45 to 60 pounds phosphate per acre, Figure 2.

Greenhouse work in Minnesota and Nebraska indicate that early sugar beet growth is enhanced with starter placement of phosphorus, but there is a difference in the placement of the starter band. Placement with the seed or two inches below the seed was superior to the more conventional placement of two inches to the side and two inches below the seed. If you choose to use the seed placement option, there are cautions on the amount which can be applied. **Applying greater than five pounds per acre of N + K_2O in contact with the seed can reduce plant stand emergence.** The amount of P in contact with the seed has not been detrimental to plant stands. The occurrence of stand reduction increases with decreasing soil moisture condition at the time of planting.

The source of starter fertilizer is not a factor in getting a yield response. Dry and liquid starter fertilizer sources will perform similarly. The only difference is the amount that can be applied in contact with the sugar beet seed. Common phosphorus fertilizer sources which can be used and their maximum recommended application amounts are listed in Table 4.

Potassium

At this time, the use of a starter fertilizer with potassium is not recommended because there is little research on the effect these sources have on sugar beet growth and only a small amount of the sugar beet growing areas need potassium fertilization. Potassium is essential to sugar beet production and is not mobile in the soil. The soil test is based on an ammonium acetate extraction on a surface six to eight - inch deep soil sample. If the soil test is in the responsive range, placement can be similar to phosphorus except extreme caution should be exercised when placing in

contact with the seed. Potassium is not a large concern in Southern Minnesota because the majority of the soils where sugar beet is grown are natively high in potassium.

Other Nutrients

There has been no documented yield or quality responses to other nutrients such as sulfur, zinc, magnesium, calcium, boron, or sodium in Southern Minnesota sugar beet growing area.

Nutrient Concerns for Crops Following Sugar Beet

Work from North Dakota State and the University of Minnesota's Northwest Research and Outreach Center indicate that nitrogen credits should be given for nitrogen in the sugar beet tops for crops such as small grains and corn grown after the sugar beet crop in rotation. If sugar beet top growth is lush and green, the credit could be as great as 70 pounds N per acre. Research in southern Minnesota has not confirmed the N credit of sugar beet tops for corn production following sugar beet in the rotation. If you are growing corn following sugar beet in the rotation, you should consider using a starter application of 40 pounds phosphate per acre. If the EDTA zinc soil test is low, also include two pounds of zinc in the starter.

Table 1. Nitrogen, phosphate, and potash recommendations for sugar beet grown in Southern Minnesota.

		Soil test phosphorus, ppm					Soil test potassium, ppm				
		VL	L	M	H	VH	VL	L	M	H	VH
Soil nitrate-N plus	Bray P1	0-5	6-10	11-15	16-20	21+					
fertilizer N required	Olsen P	0-3	4-7	8-11	12-15	16+	0-40	41-80	81-120	121-160	161+
lb/acre-2' lb/acre- 4'		-------- lb P_2O_5/acre --------					-------- lb K_2O/acre --------				
80 100		80	55	35	10	0	110	80	50	0	0

Table 2. Sugar beet yield and recoverable sugar produced as affected by frequency of application of fertilizer nitrogen.

---------- Time of N application ----------					
Preplant	4-leaf	4-leaf + 3 weeks	4-leaf + 6 weeks	Root yield	Recoverable sucrose
---------- lb N/acre ----------				tons/acre	lb/acre
0	0	0	0	14.8	4769
20	20	20	20	17.2	5300
40	40	0	0	16.6	5546
40	0	40	0	17.1	5366
40	0	0	40	17.2	5231
0	40	40	0	17.4	5423
0	40	0	40	16.6	5123
0	0	40	40	16.9	5149
80	0	0	0	17.7	5470
			$LSD_{0.05}$	1.5	485

Table 3. Effect of previous crop on sugar beet quality in Southern Minnesota.

	2006	2007	2008
Previous crop	---------- Extractable sucrose (lb/acre) ----------		
BtRR corn	7386	7927	9058
Conventional corn	8001	7887	9106
Soybean	8463	8512	9005
Sweet corn	8668	8739	9213
Spring wheat	8978	9087	9179
P>F	0.02	0.02	NS

Table 4. Common starter phosphorus fertilizer sources and maximum amounts suggested for seed application.

Source	Name	Dry or liquid	Maximum amount to apply	Phosphate supplied (lb/acre)
10-34-0	Ammonium polyphosphate	liquid	4 gallons/acre	16
18-46-0	Diammonium phosphate	dry	28 pounds/acre	13
11-52-0	Monoammonium phosphate	dry	45 pounds/acre	24
0-44-0	Triple super phosphate	dry	No limit	NA

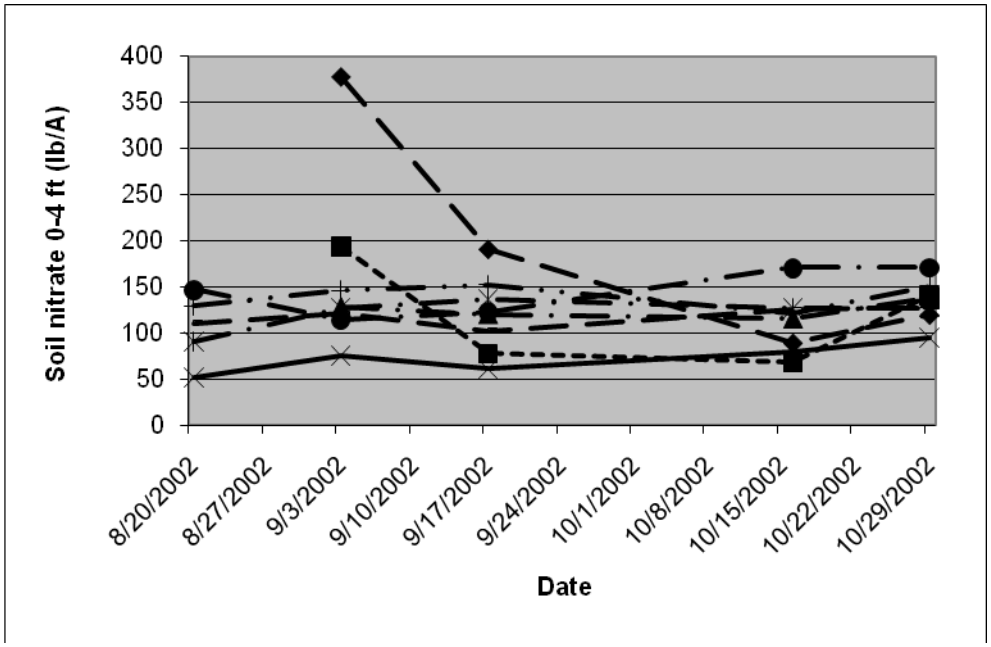

Figure 1. The effect of time of soil sampling on amount of nitrate-nitrogen in the surface four feet.

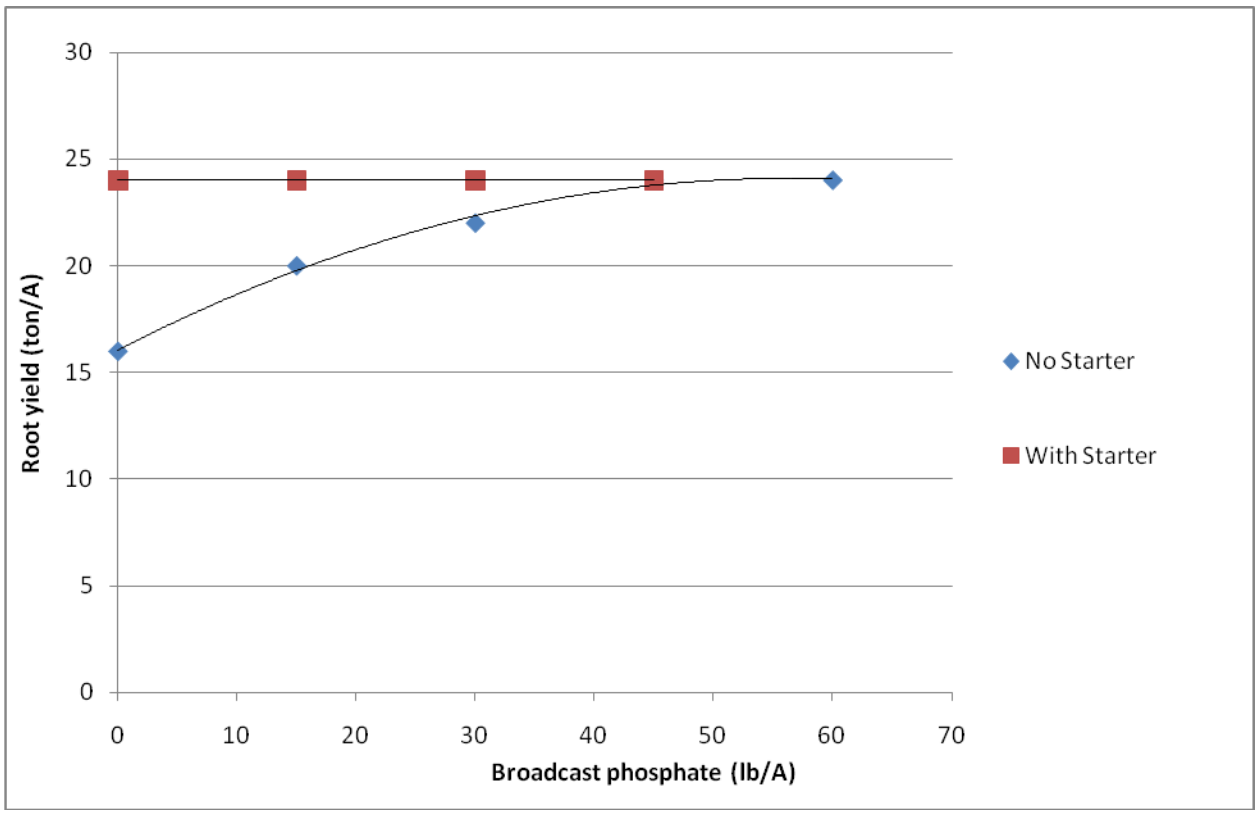

Figure 2. The effect of broadcast phosphate fertilizer with and without 3 gallons of 10-34-0 starter fertilizer.

Related Publications

08560 (Revised, 2008) – Best Management Practices for Nitrogen Use in Minnesota
www.extension.umn.edu/distribution/cropsystems/DC8560.pdf

08558 (Revised, 2008) – Best Management Practices for Nitrogen Use in Southwestern and West-Central Minnesota www.extension.umn.edu/distribution/cropsystems/DC8558.pdf

AG-FO-03553 (Revised 2007) – Manure Management in Minnesota
www.extension.umn.edu/distribution/cropsystems/DC3553.html

AG-FO-3790 (Revised 2006) – Fertilizing Corn in Minnesota
www.extension.umn.edu/distribution/cropsystems/DC3790.html

FS-03813-GO (Revised 2001) – Fertilizing Soybean in Minnesota
www.extension.umn.edu/distribution/cropsystems/CD3813.html