NITROGEN AND POTASSIUM EFFECTS ON SUGAR BEET QUALITY

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Justification of Research: Growers in the Southern Minnesota have been concerned about potassium nutrition in sugar beet. Some of this concern comes from the increase in the number of potassium soil test values from production fields that are decreasing into the 100 to 120 ppm range. The concern is about loss of root yield from the lower soil test values and the loss of quality if potassium fertilizer is applied. Little research has been done on potassium in the Southern Minnesota Beet Sugar Cooperative growing area. There is a need to investigate this.

Summary of Literature Review: The current fertilizer recommendations for growing sugar beet in Minnesota include the use of potassium when soil test values are below 120 ppm, (Lamb et. al 2001). At that time the optimum N guideline was 130 pounds per acre. The amount of N was from soil nitrate-N to a depth of 4 feet. Potassium use for sugar beets grown in Minnesota was investigated in 1985, Lamb 1986. In this study, potassium was looked at as part of a nitrogen, phosphorus, and potassium factorial. There were only a couple of application rates and the rates did not cover a wide range. The combination of nitrogen and potassium could lead to increased efficiency of the plant use.

Objectives:

1. Determine the effect of nitrogen and potassium applications on sugar beet root yield and quality.

Materials and Methods: An experiment at five locations was established in the Southern Minnesota Beet Sugar Cooperative growing area, 3 in 2010 and 2 in 2011. One of the two sites in 2011 was lost because of the wet planting conditions in May. The experiment included the factorial combination of four nitrogen application rates (0, 40, 80, and 120 lb N/A) and six potassium rates (0, 30, 60, 90, 300, and 500 lb K_2O/A). The two highest potassium rates are extreme to assess the effect of potassium on the root quality, percent sucrose and beet purity. The study will have five replications. During the 2011 growing season (July) petioles from the most recently matured leaves were sampled to determine the effect of the treatments on the sugarbeet plants. In October sugarbeet roots were harvested. Root yield and quality were determined.

Results and Discussion:

Soil Test: The initial soil test for the site is reported in Table 1. The 1073 and 1172 sites are irrigated sandy soils while the other soils are glacial till soils with a texture of silty clay loam. The potassium soil tests for 3 of the 4 sites are in the marginal range. The 1075 would be considered very high.

Table 1. Initial soil test values for the sites in 2010 and 2011.

Soil test	1073 (Elrosa)	1074(RRF)	1075(Maynard)	1172(Sudan)
pH	6.7	6.6	7.9	6.3
Organic matter (%)	4.1	2.6	NA	4.0
Nitrate-N 0-4 ft. (lb./A)	62	25	111	30 (0-2ft)
Olsen – P (ppm)	10	20	6	15
K (ppm)	127	139	177	120

Root Yield: Sugar beet root yield was increased at two of the four sites by the application of nitrogen fertilizer, Table 2 and Figures 1 and 2. Increases in root yield also occurred that same sites with potassium application. At both sites there was an interaction between the root yield responses from N application and K applications. The interaction at the 1075 caused the response required more nitrogen, 80 lb. N/A for optimum root yield at the 0 and 30 lb. K_2O/A rates while the optimum was 40 lb. N/A for the sugar beet roots grown at greater rates of potassium.

Table 2. Statistical analysis for root yield for sites in 2010 and 2011.

Statistic	1073	1074	1075	1172
N rate	0.72	0.25	0.0001	0.0003
K rate	0.13	0.13	0.0002	0.0001
N rate X K rate	0.13	0.07	0.008	0.05
C.V. (%)	9.2	6.9	6.0	18.2

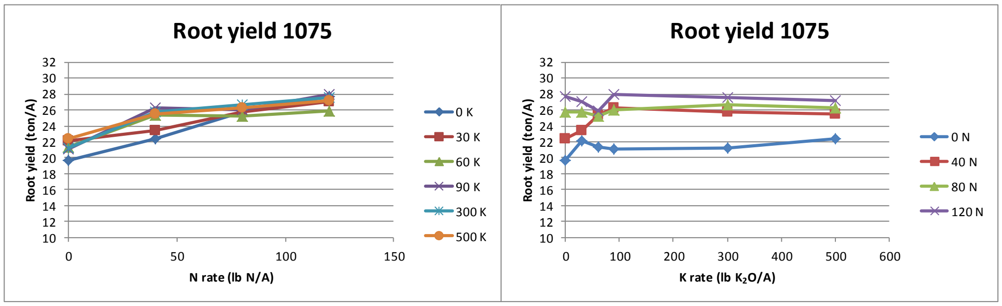

Figure 1. Root yield response to nitrogen and potassium at site 1075 in 2010.

The root yield at site 1172 was affected by the wet weather and disease in 2011, Figure 2. The root yields were as small as 10 ton/A and as large as 22 tons. There is no trend in the interaction between nitrogen and potassium at this site.

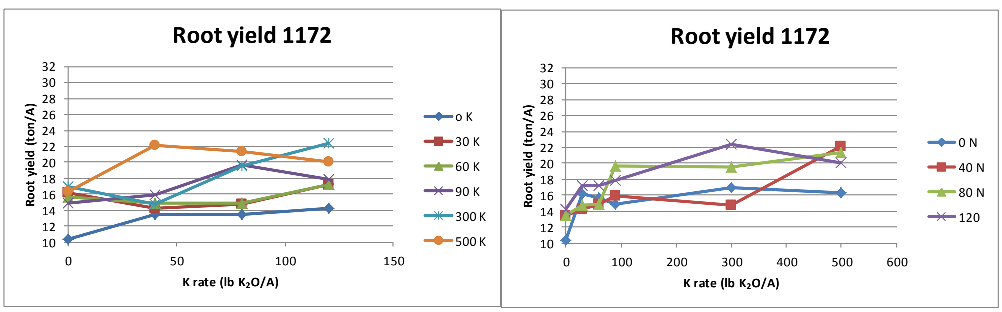

Figure 2. Root yield response to nitrogen and potassium at site 1172 in 2011.

<u>Extractable Sucrose per ton:</u> Nitrogen reduced extractable sucrose per ton at three of the four sites, Table 3. Potassium increased extractable sucrose per ton at two of the four sites.

At site 1075, the addition of nitrogen decreased extractable sucrose per ton from 288 lb. /ton to 278 lb. /ton, Figure 4. Potassium did not affect extractable sucrose per ton at this site.

At sites 1074 and 1172, nitrogen application decreased extractable sucrose per ton, Figures 5 and 6. This has occurred several times in nitrogen studies through the years. Nitrogen is an impurity in the sugar beet. At these same sites, potassium application increased extractable sucrose per acre, Figures 5 and 6. This is unexpected. Potassium is an impurity in the sugar beet that makes extraction of sucrose more difficult. The main increase at site 1074 occurred for the first 90 lb. K_2O/A while about that the response leveled out. At site 1172 the increase in extractable sucrose per ton increased up to the greatest K_2O rate of 500 lb. /A.

Table 3. Statistical analysis for extractable sucrose per ton for sites in 2010 and 2011.

Statistic	1073	1074	1075	1172
N rate	0.40	0.0001	0.06	0.02
K rate	0.86	0.003	0.46	0.0001
N rate X K rate	0.17	0.02	0.34	0.49
C.V. (%)	4.5	2.5	4.6	5.0

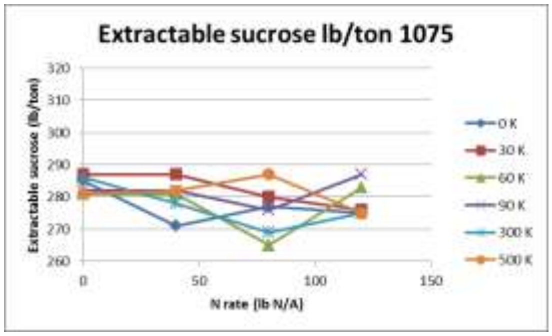

Figure 4. Extractable sucrose per ton to nitrogen for site 1075 in 2010.

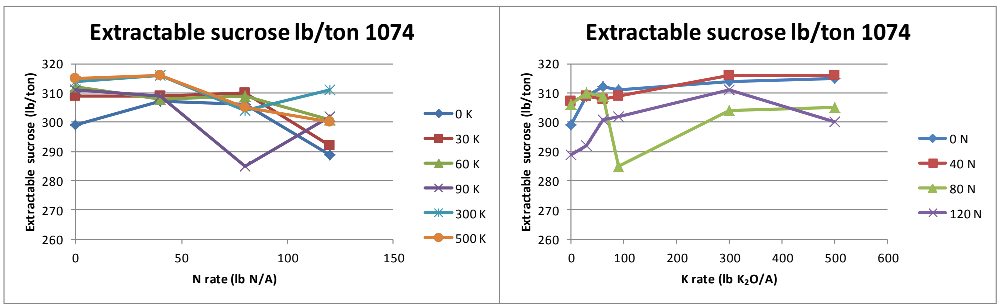

Figure 5. Extractable sucrose per ton to nitrogen and potassium for site 1074 in 2010.

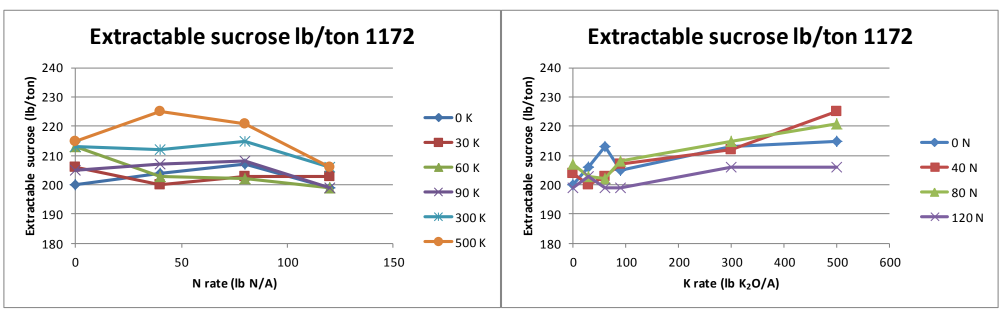

Figure 6. Extractable sucrose per ton to nitrogen and potassium for site 1172 in 2011.

Extractable Sucrose per acre: Extractable sucrose per acre was significantly affected by nitrogen application at sites 1074, 1075, and 1172, Table 4. Extractable sucrose per acre decreased with the addition of nitrogen at site 1074, Figure 7. This is a combination of the lack of root yield response to nitrogen and the decrease in quality for the application of nitrogen. There was not significant effect from the application of potassium.

At site 1075, extractable sucrose per acre was increased by application of both nitrogen and potassium, Figure 8. The optimum nitrogen rate was 80 lb. N/A for the 0 and 30 lb. K_2O/A rates and 40 lb. N/A for the 60, 90, 300, and 500 lb. K_2O/A rates. This would make the optimum N of 150 to 190 lb. N/A, soil test nitrate-N to four feet plus fertilizer N.

Nitrogen and potassium applications increased extractable sucrose per acre at the 1172 site, Figure 9. The response to potassium was greater than the response to nitrogen. This site was an irrigated sandy soil site and it was expected to respond to nitrogen and potassium application. With the above normal precipitation in 2011 movement in the soil of both N and K would be expected.

Table 4. Statistical analysis for extractable sucrose per acre for sites in 2010 and 2011.

Statistic	1073	1074	1075	1172
N rate	0.24	0.007	0.0001	0.002
K rate	0.31	0.22	0.01	0.0001
N rate X K rate	0.29	0.03	0.07	0.02
C.V. (%)	9.2	6.8	8.2	19.5

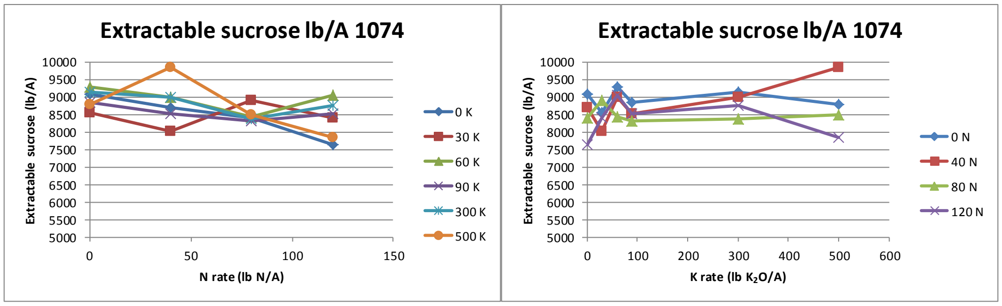

Figure 7. Extractable sucrose per acre to nitrogen and potassium for site 1074 in 2010.

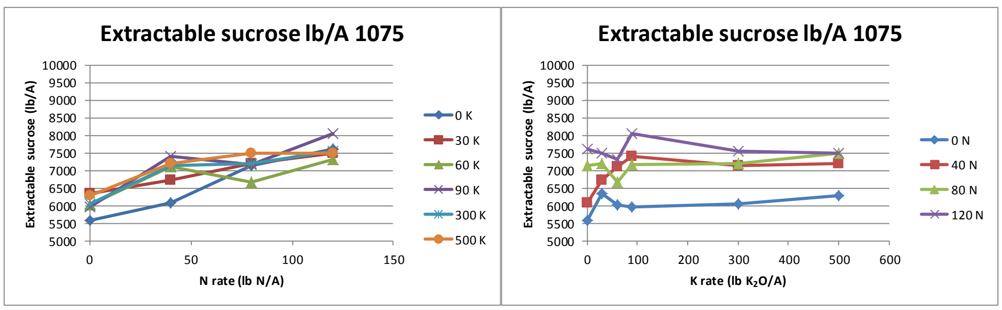

Figure 8. Extractable sucrose per acre to nitrogen and potassium for site 1075 in 2010.

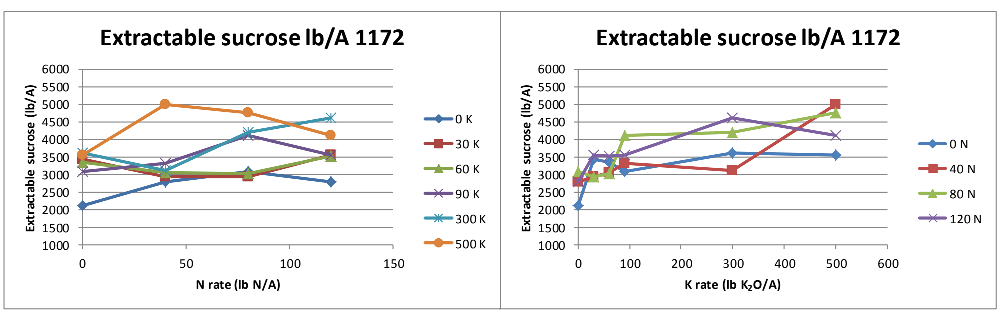

Figure 9. Extractable sucrose per acre to nitrogen and potassium for site 1172 in 2011.

Petiole Nitrate-N: Samples were taken from the most recently mature petioles in each plot at 1172 in 2011. The addition of nitrogen fertilizer increased the nitrate-N concentration in the petioles, Figure 10. The addition of potassium fertilizer decreased the concentration of nitrate-N in the petioles. This has been reported in potato petioles. This reduction in nitrate-N may explain the increase in quality from the addition of potassium even though potassium in an impurity.

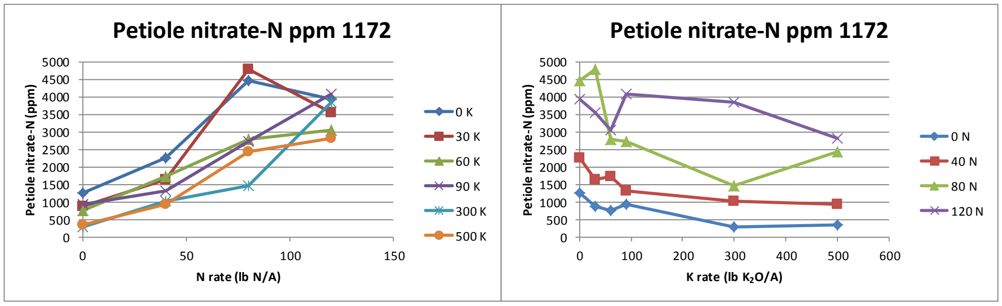

Figure 10. Petiole nitrate-N concentration as affect by nitrogen and potassium application at site 1172 in 2011.

Conclusions: Nitrogen application increased root yield at 2 of 4 sites. The use of potassium increased root yield at 2 of 4 sites. Nitrogen reduced quality at 3 of 4 sites. This was expected. The use of potassium increased quality at 2 of 4 sites even though potassium is an impurity in the extraction process. Nitrogen and potassium affected extractable sucrose per acre at 3 sites. Nitrogen increased extractable sucrose per acre at two sites and decreased it at one site. The reduction in extractable sucrose per acre is also the site where root yield was not affected by nitrogen and the quality was reduced by nitrogen application. In 2011, petiole nitrate concentrations from samples taken in mid-July were increased with the addition of N fertilizer while the addition of K fertilizer reduced it. The results reported are the produce of two years of work and because of the wet weather in 2011 should not be used with future information.

Literature Cited:

Lamb, J.A., A.L. Sims, L.J. Smith, and G.W. Rehm. 2001. Fertilizing Sugar Beet in Minnesota and North Dakota. Univ. Minn. Ext. Ser. FO-07715-C 2001

Lamb, J.A. 1986. Effect of phosphorus and potassium fertilization on yield and quality of sugar beet grown in West Central Minnesota. In 1985 Sugarbeet Res. and Ext. Rpts. 16:98-102.