High sugarbeet yields are dependent on good stands, healthy beets, and a good and balanced supply of available nutrients, particularly nitrogen (N), phosphorus (P), and potassium (K). Nitrogen management for a high yielding and high quality sugarbeet crop can be difficult. Too little N reduces yields, while excess N at the end of the growing season reduces quality, and costs the producer excessive fertilizer expense. Excess N can also be an environmental contaminant, caused by leaching or run-off.

Residual soil N is an important factor in managing N for high quality sugarbeets, so soil sampling is a key to quality fertilizer application. Value of a soil test to predict nutrient availability during the growing season is directly related to how well the sample represents the area sampled. Studies in Michigan reported that most N uptake occurs in the top two feet of soil, and only about 30% of the N from greater depths was used. In Nebraska, sugarbeets took up slight amounts of N at depths up to eight feet by mid-season, and by the end of the season, took up large amounts from depths up to seven feet. The difference in these two studies is probably due to the length of the growing season.

Rate of applied N is usually determined using a nitrogen budget based on expected yield, residual soil N, and organic matter (OM). Several budgets have been developed for different sugarbeet growing areas. Halvorson and Hartman did much research in Sidney to determine a nitrogen budget for that area. They recommended 10 lb N/ac for each ton of expected yield, with applied N calculated as follows:

\[
\text{Applied N} = \text{N requirement} - \text{residual soil N}_{0-4 \text{ ft}} - \text{N released from OM} + \text{N used by residue of previous grain crop (or} - \text{N released by previous legume crop) .}
\]

Nitrogen released from OM was considered to be 30 lb/ac for each 1% OM, and straw use was considered to be 20 lb N/ac for each T of residue. They recommended that sugarbeets not be grown after a legume crop, since N from such a crop can be released late in the season, at a time when excess N is detrimental to sugarbeet quality. The N budget used in Colorado is the same, with a maximum N requirement of 200 lb N/ac.

The applied N rate recommended by Sidney Sugars in the Mondak area today differs somewhat from this budget. The recommended rate is 8 lb N/ac for each ton of expected yield, with the rate calculated thus:

\[
\text{Applied N} = \text{N requirement} - 100\% \text{ residual soil N}_{0-2 \text{ ft}} - 80\% \text{ residual soil N}_{2-4 \text{ ft}} - \text{N released from OM}
\]

Nitrogen released from OM is considered to be 25 lb/ac for each 1% OM in this budget. Much debate exists about N rates for early and late harvested sugarbeets. Growing season conditions vary greatly from year to year in the lower Yellowstone River
Valley, making precise predictions about sugarbeet N needs at various harvest dates difficult. Conditions at harvest can also vary greatly, and exact early harvest dates are often not known until a few days or weeks before harvest begins. Thus, recommended rates of applied N must necessarily be general in the lower Yellowstone River Valley, as opposed to more precise recommendations in other areas. A study in Sidney showed that the N rate currently recommended for sugarbeet production in the lower Yellowstone River Valley is sufficient for sugarbeets harvested late in the season, and is usually not detrimental to sugarbeets harvested during the early harvest period.

Poor irrigation management reduces the effectiveness of the best N management practices. Excess run-off or leaching increases fertilizer costs and contributes to ground and surface water contamination. A study in Texas sampled soil under several fields of furrow-flood irrigated sugarbeets. Soil at the lower ends of the fields had greater soil N than soil from the upper ends of the fields. This was attributed to movement of N with the irrigation water. A study in Bozeman, MT, showed that more nitrate leaching occurred with high volume-low frequency irrigations (as in flood irrigation), while very little leaching occurred when irrigations were low volume-high frequency (as in sprinkler irrigation).

A six-year study at Sidney evaluated sugarbeet response to furrow-flood irrigation and sprinkler irrigation. Sugarbeets under both systems were fertilized based on the budget system developed by Halvorson and Hartman. Sugarbeets were planted to-stand in a commercial field at the MSU Eastern Agricultural Research Center from 1997-2002. Half of the field was irrigated using furrow-flood irrigation (3.0 inches for each irrigation) and the other half was irrigated using a low-pressure overhead linear sprinkler system (1.0 inch for each irrigation). Sugarbeets under the sprinkler were irrigated more often than flood-irrigated beets, but less water was applied with each irrigation.

Wells that reached the ground water were placed at each end of each irrigation system. Ground water was sampled for nitrate content throughout the growing season. Water samples were collected by pumping each well dry, then collecting recharge water. Samples of irrigation and run-off water were also collected for evaluation of nitrate content.

Type of irrigation did not affect plant populations or tare across years. Plant population under sprinkler irrigation was usually greater than population under flood irrigation in years with dry conditions at planting, although not always significantly so. Plots were irrigated early in those years to improve emergence, and sprinkler irrigation appeared to be more effective when irrigating the crop up, although seedling stands were not determined.

Root yield was significantly greater under flood irrigation than under sprinkler irrigation in four of the six years tested, but when averaged over years, the difference was not significant. Sucrose content was significantly greater under flood irrigation than under sprinkler irrigation in three of the six years, but was not significantly greater when averaged across years.

Quality of the sugarbeets under the sprinkler was lower than that of the sugarbeets under the flood irrigation. The impurities sodium (Na), potassium (K), and amino-N were greater under sprinkler irrigation than under flood irrigation every year, significantly so in four years, and the differences were significant when averaged over years. Because of
their higher impurity content, sugarbeets under sprinkler irrigation had greater loss to molasses (SLM) and lower extraction than flood irrigated sugarbeets.

Irrigation water running off the lower end of the furrow-flood irrigated fields contained more nitrate than the irrigation water coming onto the top of the field early in the growing season. Sprinkle irrigation had no run-off so no N was lost by that route. Fields in which run-off occurs during sprinkle irrigation events would probably lose nitrate in run-off water. Ground water under the flood irrigated beets often had higher nitrate content than ground water under the sprinkler. In some years, ground water nitrate under flood irrigated sugarbeets continued to increase throughout the growing season. Nitrate concentration in the ground water generally increased sooner and more rapidly under flood irrigation than sprinkle irrigation, and remained high throughout the season. The greatest concentration of nitrate was often detected under the lower end of the flood irrigated sugarbeets, while little difference was detected in nitrate concentration of ground water under the upper and lower ends of the sprinkle irrigated sugarbeets.

Sugarbeets had greater sucrose content, root yield and sucrose yield, lower impurities and greater extraction under flood irrigation than under sprinkle irrigation. Ground water under flood irrigation had greater nitrate concentration than ground water under sprinkler irrigation, especially at the lower end of the field. Run-off water from flood irrigation had greater nitrate concentration than the irrigation water applied to the field. These data indicate that sprinkle-irrigated sugarbeets probably need less applied N than flood-irrigated sugarbeets because of less loss to leaching and run-off, suggesting that a different N budget should be developed for sprinkler irrigated beets. A study comparing different N rates under sprinkle and flood irrigation was initiated at Sidney.

Table 1. Six-year averages of yield and quality of sugarbeets grown under sprinkler and furrow-flood irrigation. Different numbers in the same column indicate significant differences at a probability of less than 0.05%.

<table>
<thead>
<tr>
<th>Irrigation system</th>
<th>Root yield T/ac</th>
<th>Percent Sucrose</th>
<th>Sucrose yield lb/ac</th>
<th>Na, ppm</th>
<th>K, ppm</th>
<th>Amino-N, ppm</th>
<th>SLM</th>
<th>Percent extraction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sprinkler</td>
<td>25.4</td>
<td>17.17</td>
<td>8713</td>
<td>501b</td>
<td>1809b</td>
<td>270b</td>
<td>1.33b</td>
<td>92.1a</td>
</tr>
<tr>
<td>Flood</td>
<td>27.6</td>
<td>17.65</td>
<td>9742</td>
<td>347a</td>
<td>1616a</td>
<td>175a</td>
<td>104a</td>
<td>94.0b</td>
</tr>
</tbody>
</table>