# ON-THE-GO SENSING TECHNIQUES FOR SUGAR DETERMINATION OF SUGARBEET IN THE FIELD

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**Introduction:**

The advancement of sensing and sensor technologies has enabled us to improve upon the previously developed sugar content determination system for sugarbeet. The more reliable and efficient components have greatly improved the accuracy of the sensing system and moved the system one step closer to the ultimate on-the-go concept. An in field sugar sensor must be small in size, portable and rugged for use in the field.

Producing a sugar content map along with a yield map will help a producer determine the pounds of sugar from a particular place in a field. This can be helpful for future crop production which can help in soil sampling and fertilizer application. This type of information can be useful similar to a yield map from a combine yield monitor.

**Objective:**

The objective of this research is to develop an on-the-go sensor for the determination of sugar content of sugarbeets in the field during harvest and produce a sugar contour map.

**Procedure:**

A new integrated system was developed and used to acquire the NIR reflectance (absolute) signal of sugarbeet samples. The system consists of a PC-based fiber optic spectral meter along with the sensor head, a tungsten halogen lamp, and a sample holder. Initially, experiments were conducted to optimize different optical configurations for signal acquisition..

In 2001, a total of 130 bags of sugarbeet from two different fields were harvested to validate our previously developed sugarbeet models. On September 24th, 100 bags of sugarbeet samples were taken from one field near St. Thomas, ND and on October 3rd; another 30 bags of sugarbeets were taken from a field near Hillsboro, ND. From the first 100 bags of beets, two beets were randomly selected from each bag; a thin slice of the crown was removed to expose the beet center. Then the reflectances of the samples were taken using the instrument developed previously. The beets were put back into the bag and all bags were analyzed for sugar content at the American Crystal tare lab. There were several beets in each bag (8 to 12) and the actual sugar content analyzed from tare lab represents the average sugar content of the whole bag. For the last 30 bags, every beet in the bag was cut and reflectance spectrum readings were taken. Again, the average sugar content was obtained for each bag at the tare lab. This sampling technique is very similar to the one used by growers.

The reflectance spectrum of the beet was obtained by placing the sugarbeet 4 in. from the light source and 6.25 in. from the sensor at a 40° angle. The light spectrum ranges from 900 nm to 1700 nm with a 0.5nm resolution. A 400-micron IR/VIS fiber optic is used to transmit the signal from the sensor to the spectrometer.

The required images were further processed using different signal processing techniques. The statistical technique “partial least squares regression” was used to develop prediction model for predicting sugar content.

**Results:**

For the first 100 bags of beets, the average prediction accuracy is 88.03% with r-value of 0.34 when plot actual versus predicted sugar content. For the last 30 bags of beets, the average prediction accuracy is 81.03% with r-value of 0.63. These statistical results are shown in Figures 1 and 2.

The results are not as good as previous years due to several reasons. First, the actual sugar content is determined for the entire bag while the signals of each beet or part of the beets in the bag were taken. Therefore, predicted sugar content is more closely related to individual beets while the actual sugar is of all the beets in the bag. Even if the average of all the beets in a bag was taken as the predicted sugar content, its correlation with the actual sugar content was expected to be poor. The actual sugar content of the entire bag is not the average of each individual beet but all the beets as a whole when they were ground and mixed. The other factor that has affected the accuracy is the hand placement of the beet when acquiring signals. Last year's test is based on a slice of beet that can be fixed on our instrument. This year, we have the whole beet with only the crown cut off. There is no mechanical device available to hold the whole beet in place when taking readings. Therefore, hand movement is not very steady and cannot keep a constant distance from the light source. Accuracy of the results was affected.

In previous years, we were taking readings near the center of a beet and actual sugar contents were determined from a slice through the same part of the beet. This year, the readings were taken directly under the beet crown after a fresh cut was made. The values obtained will be lower due to the point where sensing was done. The actual values were obtained as an average for the entire bag. A correction factor will need to be determined to adjust the sensor readings to more accurately predict the actual sugar values of beets.

We foresee that if we can design a mechanical device that will maintain beets at a constant distance from the light source and the sensor, we can obtain results similar in accuracy to previous years. This study implies that the sampling techniques commonly used does not provide a good way to determine actual sugar content of individual beets and should not be used to validate this type of sensor.

Figure 3 shows contour maps made by collecting the 30 sugar samples at various places in a 10 acre beet field. GPS readings were recorded. The sugar was measured with the sugar sensor and the actual sugar was determined at the American Crystal tare lab (data is listed in figure 1). The data was installed in a GIS software package to produce a contour map of both sugar analysis methods. The two maps are similar but the predicted values with the NDSU sensor are lower than the actual values by about 3.5 points of sugar. The differences were explained earlier.

**Conclusion:**
From this study during the past several years, it is concluded that the modified NIR sensor can predict sugar content of sugarbeet with very high accuracy. The design of the unit suggests that a portable integrated system is the next step so the unit can be taken to the field. This will require that a compact sugar sensor including a light source, receiver, a compact spectrometer and notebook computer be assembled. This unit will need to be calibrated, tested and packaged for commercial sale. This will need to be done by a commercial business.

**References:**


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**Figure 1. Performance of a Validation Model to Predict Sugar Content of Sugarbeet Using Standard Reference Elimination Technique & PLS (27 Components) Model (30 bags)**

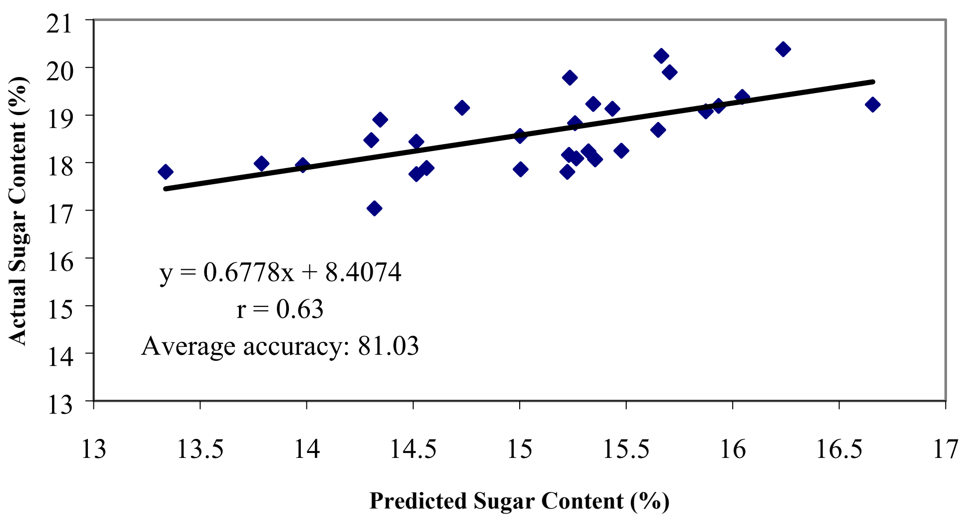


**Figure 2. Performance of a Validation Model to Predict Sugar Content of Sugarbeet Using Standard Reference Elimination Technique & PLS (27 Components) Model (100 bags)**

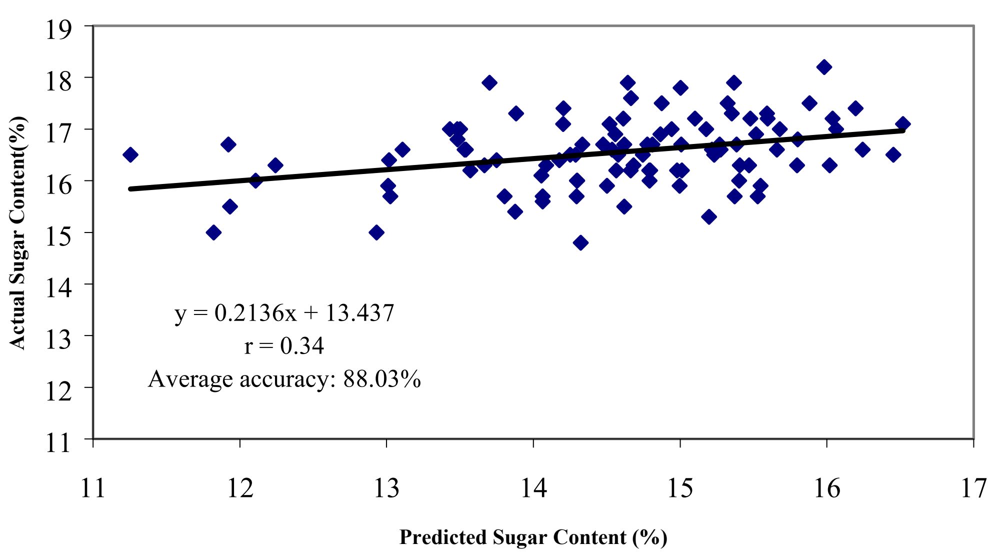

**Figure 3. Contour maps of predicted and actual sugar percentages harvested from a ten acre field.**