SUGARBEET YIELD PREDICTION USING ACTIVE-OPTICAL SENSORS

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INTRODUCTION

Active-optical (AO) sensors suitable for commercial use have been available for about ten years. The first AO sensor developed for yield prediction and for use in directing in-season N applications was the GreenSeeker™ (Trimble, Sunnyvale, CA). This instrument was developed at Oklahoma State University by W.R. Raun, a soil scientist, J. Solie, and M. Stone, agricultural engineers. Additional information on the development of the instrument and the calibration advancements in yield prediction and in-season N prediction can be found on-line at http://www.nue.okstate.edu . The objectives of our study was to investigate the relationship between AO sensor readings and sugar beet yield and quality in order to build a data base to support a yield prediction algorithm that could be used by both growers and their sugar beet company partners for both harvest logistics and in-season N application direction.

METHODS

Sites were established at Crookston, MN and Amenia, ND in 2012, and Casselton, ND and Thompson, ND in 2013. Each site was a randomized complete block design with six N treatments (check, 30, 60, 90, 120, and 150 pounds per acre N) applied preplant within a week of seeding as ammonium nitrate, and four replications. The experimental unit was 30 feet long and 30 feet wide. Row width was always 22 inches. Cultivar was left to the discretion of the grower. Herbicide application and any other pest management treatments were applied by the grower. Sensor measurements were obtained from each plot at each location at V6 and again at V12. Sensor readings using both Red and Red Edge NDVI (normalized differential vegetative index) were made using both the GreenSeeker and Holland Crop Circle (Holland Scientific, Lincoln, NE). The GreenSeeker unit used in 2013 was an upgraded version from the one used in 2012. The 2012 version did not have the capability to utilize a Red Edge light band. The NDVI is defined as:

(near infra-red measurement – red measurement) / (near infra-red measurement + red measurement)

To normalize the measurements with growth stage, the statistic INSEY (in season estimate of yield, defined by Raun et al 2001) which is (reading / growing degree days from planting date to date of sensor reading).

Most sites were harvested three times, except at Amenia in 2012, where extremely dry soil conditions resulted in a yield plateau after the second harvest. The 2012 methods are detailed in Franzen, 2012. Harvest dates in 2013 were August 30, September 15 and September 30. At each harvest date, 10 feet of row was hand harvested, the tops removed and the beets placed in tare bags. The bags were then delivered the same day to East Grand Forks Quality Laboratory for weight and quality analysis. Statistical analysis was conducted within SAS© for treatment differences. Regression equations and graphics were generated within Excel 2010©.

RESULTS

Results for 2012 were provided in Franzen et al., 2012. In 2013, Thompson yield at the first harvest date was greater than the check at the 30 lb/acre N rate (Tables 1-3). Although there were trends in higher yield, higher recoverable sugar per acre and lower net sugar content with higher N rate, the trends were not significant. The N rates were imposed to produce a range of yields and quality that could be used to support construction of the algorithm of sensor readings to yield. All of the relationships have not been analyzed for this paper. However, analysis of several relationships in Figures 1-6 show that the four sites tested so far are part of the same data set algorithm. Both red NDVI-based INSEY and red edge-based INSEY are useful at early growth stages to relate readings to yield. The algorithms are better related to yield at later growth stages.

Table 1. First sugar beet harvest, August 27, 2013.

Site	Treatment lb N/acre	Yield, tons/acre	Net Sugar, %	Recoverable sugar per ton	Recoverable sugar per acre
Casselton	0	14.3	18.2	364	5171
	30	14.5	18.1	362	5239
	60	14.6	18.3	366	5352
	90	15.2	18.2	364	5479
	120	15.1	17.6	352	5294
	150	16.3	17.2	344	5579
LSD 5%		NS	0.9	NS	NS
Thompson	0	18.9	15.8	316	5972
	30	24.4	15.1	302	7362
	60	22.4	15.9	318	7127
	90	21.7	14.8	296	6453
	120	21.5	15.5	310	6641
	150	20.9	14.7	294	6208
LSD 5%		4.7	0.6	NS	NS

Table 2. Second sugar beet harvest, September 16, 2013.

Site	Treatment lb N/acre	Yield, tons/acre	Net Sugar, %	Recoverable sugar per ton	Recoverable sugar per acre
Casselton	0	19.2	17.0	340	6538
	30	19.7	17.1	342	6766
	60	20.1	17.0	340	6846
	90	20.2	16.8	336	6768
	120	22.0	16.4	328	7224
	150	22.8	16.1	322	7356
LSD 5%		NS	NS	NS	NS
Thompson	0	19.2	16.0	320	6920
	30	19.4	15.0	301	6685
	60	20.3	15.8	317	6906
	90	20.2	16.0	320	6768
	120	22.0	15.7	315	7224
	150	22.8	15.5	309	7356
LSD 5%		NS	NS	NS	NS

Table 3. Third sugar beet harvest, September 30, 2013.

Site	Treatment lb N/acre	Yield, tons/acre	Net Sugar, %	Recoverable sugar per ton	Recoverable sugar per acre
Casselton	0	31.1	16.0	320	9954
	30	28.7	15.0	301	8688
	60	34.4	15.8	317	10858
	90	33.0	16.0	320	10513
	120	32.4	15.7	315	10252
	150	29.8	15.5	309	9202
LSD 5%		NS	NS	NS	NS
Thompson	0	31.1	16.4	327	9953
	30	28.7	16.2	324	8687
	60	34.4	15.8	315	10856
	90	33.0	15.8	316	10511
	120	32.4	15.2	303	10250
	150	29.8	14.8	298	9200
LSD 5%		NS	NS	NS	NS

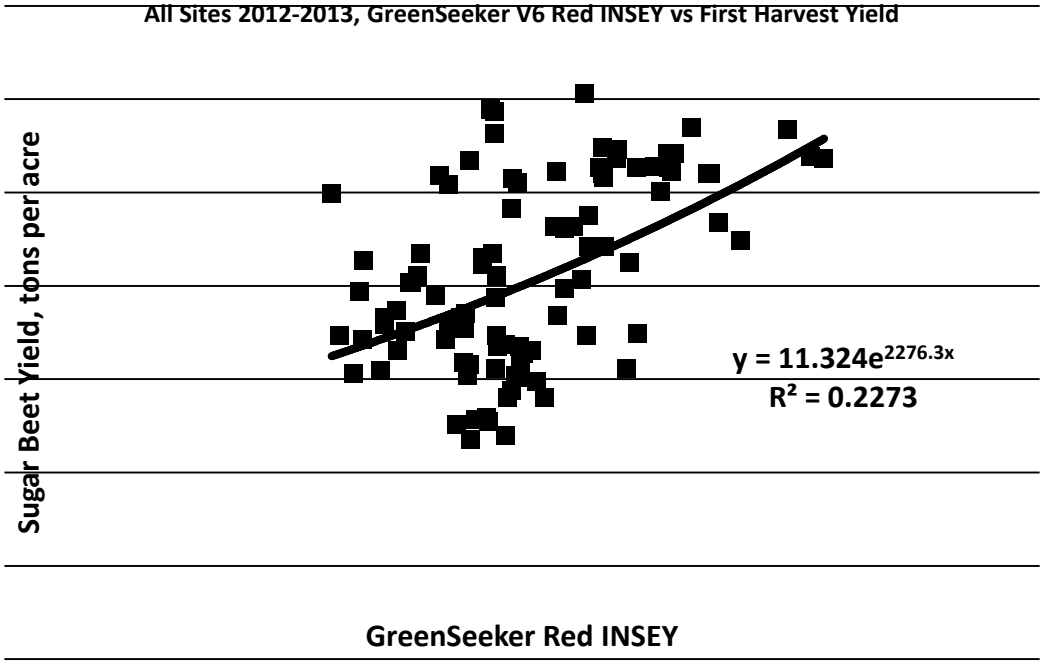

Figure 1. Relationship of GreenSeeker V6 red INSEY and harvest at the first date. In 2012 the first date was August 15 (3458 GDD) and in 2013 the first harvest date was August 27 (3615 GDD).

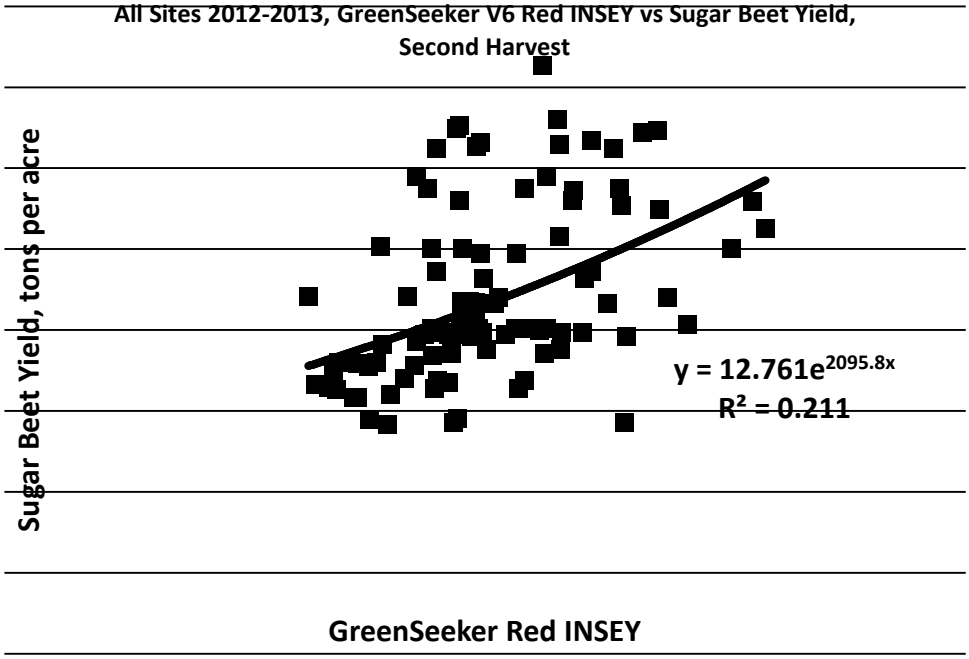

Figure 2. Relationship of GreenSeeker V6 red INSEY and harvest at the second date. In 2012 the second date was August 31 (4375 GDD) and in 2013 the second harvest date was September 15 (4267 GDD).

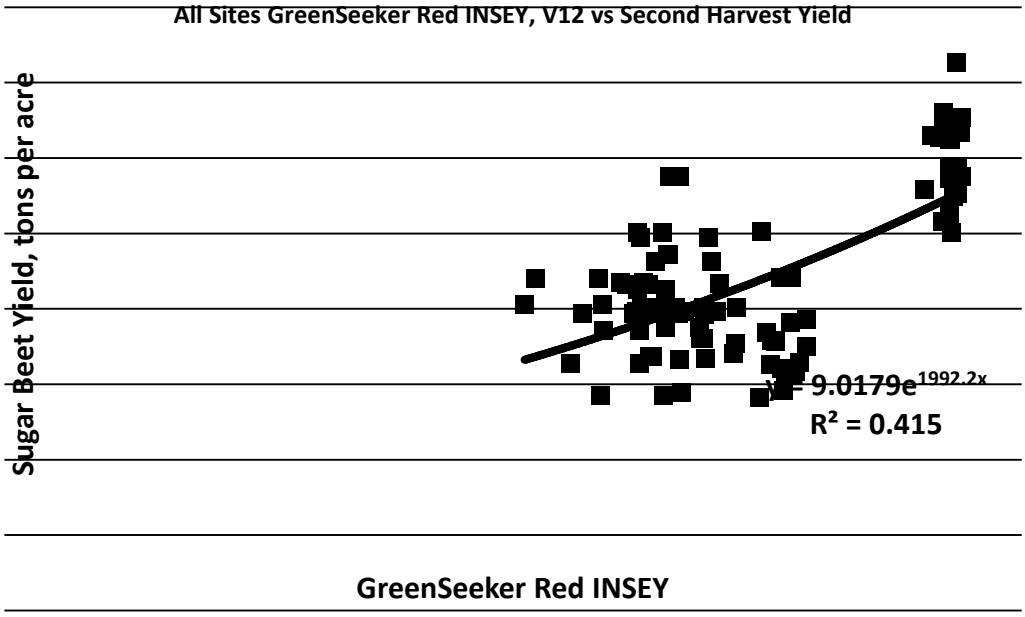

Figure 3. Relationship of GreenSeeker V12 red INSEY and harvest yield at the second date. In 2012 the second date was August 31 (4375 GDD) and in 2013 the second harvest date was September 15 (4267 GDD).

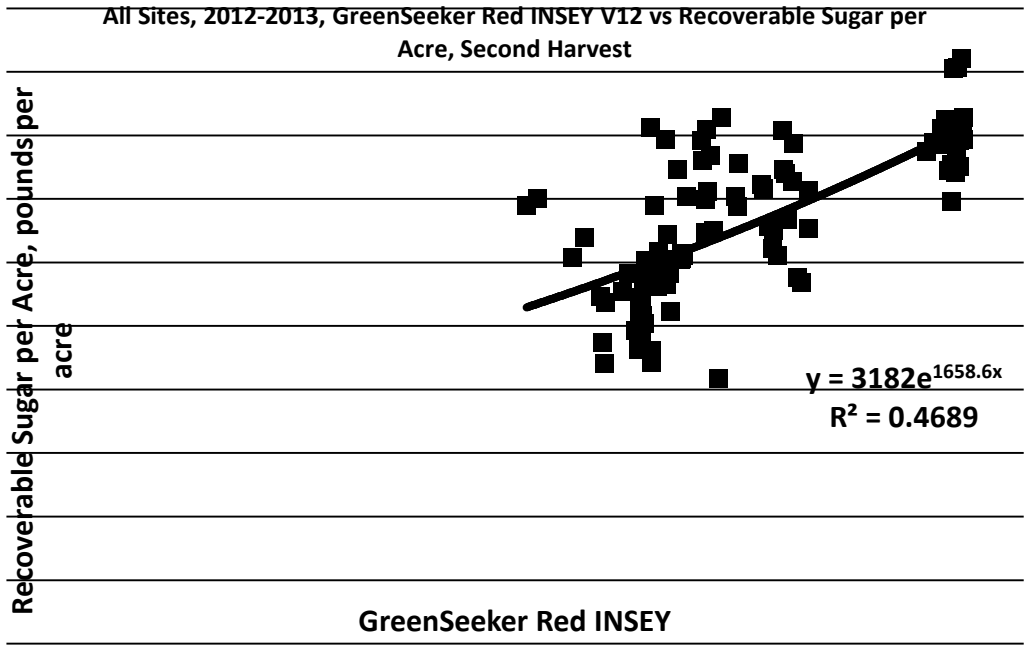

Figure 4. Relationship of GreenSeeker V6 red INSEY and recoverable sugar per acre at the second date. In 2012 the second date was August 31 (4375 GDD) and in 2013 the first harvest date was August 27 (4267 GDD).

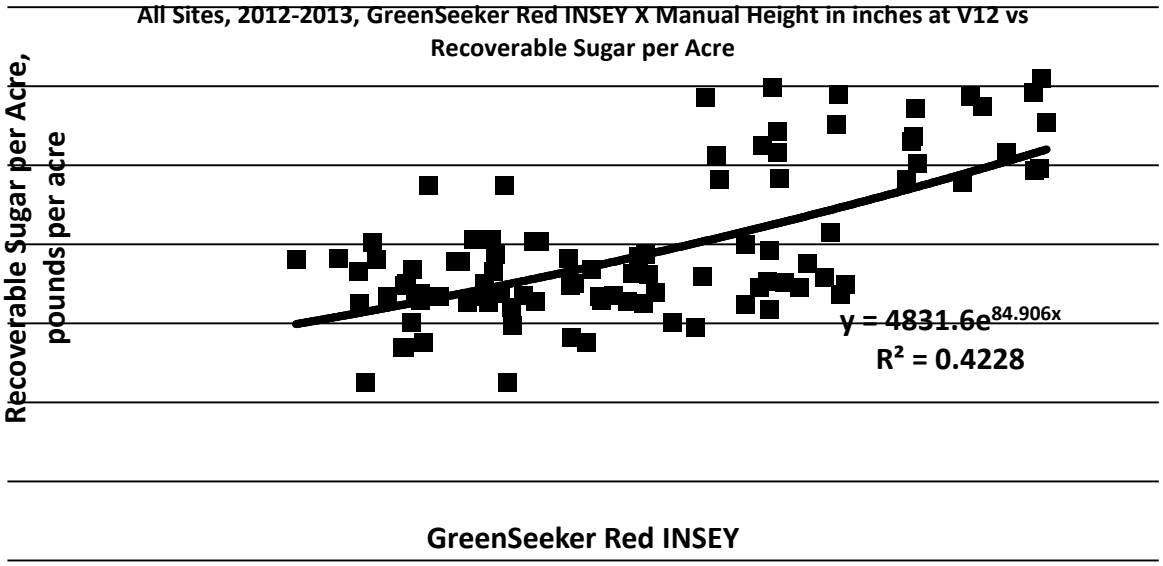

Figure 4. Relationship of GreenSeeker V6 red INSEY multiplied by manual canopy height in inches and recoverable sugar per acre at the second date. In 2012 the second date was August 31 (4375 GDD) and in 2013 the second harvest date was September 15 (4267 GDD).

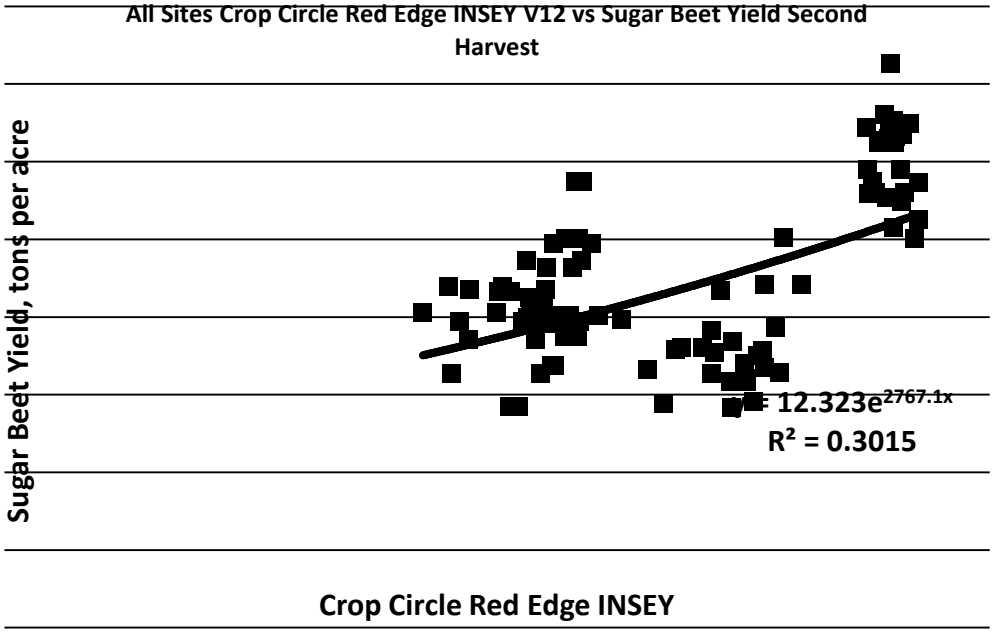

Figure 5. Relationship of Crop Circle red edge INSEY multiplied by manual canopy height in inches and recoverable sugar per acre at the second date. In 2012 the second date was August 31 (4375 GDD) and in 2013 the first harvest date was August 27 (4267 GDD).

References

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Raun, W.R., J.B. Solie, G.V. Johnson, M.L. Stone, E.V. Lukina, W.E. Thomason, and J.S. Schepers. 2001. In-season prediction of yield potential using wheat canopy reflectance. Agronomy Journal 93:131-138.

Acknowledgements

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