Project Proposal

Sugar beet Research and Education Board of MN & ND

FY 2018-2019

Soil Management for Sugar beet Production

By

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1. **Project title: Can We Predict Sugarbeet Nitrogen Response Using Drone-based Remote Sensing?**

Project description (New): Vegetation indices like NDVI and NDRE from drone-based optical sensor have shown a significant relationship with leaf nitrogen. The relationship between vegetation indices and sugarbeet yield and quality will be determined across a fertilizer-nitrogen gradient (i) 0, (ii) 130, (iii) 160 lb N/ac at two sites. Vegetation indices will be used to predict the harvesting date for optimizing yield and quality.

Project Leader:

Amitava Chatterjee (PI), Soil Science, NDSU, Fargo, ND

Other personnel involved:

Norman Cattanach, Soil Science, NDSU, Fargo, ND

Dan Olson, graduate student, Soil Science, NDSU, Fargo, ND

Project location: Ada and Sabin, Minnesota

The justification for research:

Fertilizer-N application rate is a significant decision making step in achieving yield goals. Sustainable use of fertilizer-N has potential to increase growers' economic profitability and reduce the chance of environmental consequences. Standard soil and plant tissue test procedure involve destructive sampling, are time-consuming and expensive. Active optical sensor-predicted vegetation indices like NDVI (Normalized difference vegetation index) or NDRE (Red edge-NDVI) has long been considered as a promising tool for precision fertilizer-N management. Unmanned air vehicle (UAV) or drone-based remote sensing can provide fast and sensitive canopy reflectance imagery. Drone imagery can be successfully used to predict crop- health, productivity, and quality. The main goal of this project to calibrate canopy reflectance with a crop-specific fertilizer-N response.

Summary of literature review

Crop reflectance data can be used for variable N application in crops when fertilizer-N is the main growth-limiting factor (Zillman et al. 2006, Franzen et al. 2010). Gehl and Boring (2011) concluded that active sensing during the growing season showed promise as a means to estimate sugarbeet root yield and recoverable sugar and sensing on the day of harvest may improve rotational N management by indicating N-return to the cropping system. Red-NDVI and Red edge NDVI at V6-V8 of corn and sugarbeet growth stages could be successfully used to predict yield, which would be useful in developing algorithms for in-season N fertilization (Sharma et al. 2015, Bu et al. 2016).

Bu, H., L.K. Sharma, A. Denton, and D.W. Franzen. 2016. Sugar beet yield and quality prediction at multiple harvest dates using active-optical sensor. Agron. J. 108:273-284.

Franzen, D.W., G. Richards, and T. Jensen. 2010. Precision management zones increase sugar production in North Dakota and Minnesota. Better Crops, Vol. 94(3):24-25.

Gehl, R.J., and T.J. Boring. 2011. In-season prediction of sugarbeet yield, quality, and nitrogen status using an active sensor. Agron. J. 103:1012-1018.

Sharma, L.K., H. Bu, A. Denton, and D.W. Franzen. 2015. Active-optical sensors using red NDVI compared to red edge NDVI for prediction of corn grain yield in North Dakota, U.S.A. Sensors. 15:27832-27853.

Zillmann, E., S. Graeff, J. Link, W.D. Batchelor, and W. Claupein. 2006. Assessment of cereal nitrogen requirements derived by optical on-the-go sensors on heterogeneous soils. Agron. J. 98(3): 682–690.

Objectives:

(i) On-farm, field experiments will be laid out to determine yield and quality response to different incremental fertilizer N rates for sugarbeet production

(ii) Drone-based optical sensors will be used to prepare field maps of vegetation indices (NDVI and NDRE) NDVI and NDRE during the peak growing season

(iii) Develop the calibration curves between vegetation indices and crops' yield and quality parameters across the nitrogen gradient

(iv) Determine changes in yield and quality at three harvesting times (early-end of September, middle-end of September or 1st wk of October and late-2nd wk. of October).

Materials and Methods:

In spring 2018, field trials will be laid out in randomized block design with four replications. Four fertilizer-N application rates, check, 130, and 160 lb N/ac, will be considered. Fertilizer-N treatments will be adjusted to the residual soil NO_3-N test and will be applied in the form of urea. All plots will be 55 ft long and 33 ft wide. Standard crop management and plant protection measurement will be followed. Two middle-rows will be harvested at three harvesting times, (i) early-end of September, (ii) middle-end of September or 1st wk of October and (iii) late-2nd wk. of October). Yield and quality parameters for the respective crop will be determined. Initial and after harvest soil available

nitrate-nitrogen will be determined for 0-6", 6-24", 24-48" depths.

Drone (DJI Matrice 100) attached to MicaSense RedEdge multispectral camera (red-668 nm, blue-475 nm, green-560 nm, near infrared-840 nm, and red edge-717 nm) will be used to collect the canopy reflectance imagery throughout the growing season. Drone image will be collected at Imagery will be processed using the Pix4D software. The relationship between yield and quality and vegetation indices will be established using the regression analysis using SAS 9.2 software.

Timeline of anticipated accomplishments:

Soil sampling, plot layout, fertilizer application and planting	April-May, 2018
Drone flight and image processing	June-October 2018
Harvesting	September-October 2018
Post-harvest soil sampling	October 2018

Budget:

Labor: Technician salary (for 1 month)+42% fringe benefit	4,000+1,680= $5,680
Labor: undergraduate students ($14/hr×20 hr/wk×4 wk)+10% Fringe	1,120+112= $1,232
Travel (100 miles×2 sites×10 trips×$0.50/mile)	$1,000
Land rent ($400 per acre for twos sites)	$800
Supplies (Stakes, herbicides/pesticides, tags, fertilizer, sampling bags)	$1,500
Total	$10,212

2. **Project title: Survey of Tile-drained Sugarbeet Fields for Soil Water Nitrate Concentration at 4 feet throughout the Growing Season**

Project description (New): Soil water nitrate concentration at 4 feet soil depth will be measured for nitrate concentrations for tile drained sugarbeet fields. Initial and post-harvest soil samples from 0-6 and 6-24" depths will be collected to determine the nitrogen balance. This project will provide growers an idea about the potential loss of nitrogen through leaching under sugarbeet production for varying soil type and crop management practices.

Project Leader:

Amitava Chatterjee (PI) - Soil Science, NDSU, Fargo, ND

Other personnel involved: Norman Cattanach – Soil Science, NDSU, Fargo, ND

Project Location: Ten tile-drained sugarbeet fields spread across American Crystal, MinnDak and southern Minnesota sugarbeet growing areas

Justification of Research: Sugarbeet uses nitrogen in the form of nitrate, but it is highly mobile through the soil profile and potential to leaching through soil. Leaching of nitrate may reduce the yield and may have some environmental consequences. Nitrate leaching only occurs when water is passing through the profile and depends on the amount of percolated water. Tile drainage reduces the water table depth and improves water movement through the profile. The Minnesota Department of Agriculture is developing a Nitrogen Fertilizer rule. The rule is aimed to reduce nitrate losses in areas with high measurable nitrate in groundwater. It is critical for growers to determine the quantity of nitrate leached under tile drained conditions.

Summary of Literature Review: Increasing diffuse nitrate loading of surface waters and groundwater has emerged as a major agricultural system, resulting in contamination of drinking water. Sebilo et al. (2013) found that between 8-12% of the applied fertilizer had leaked toward the hydrosphere during 30y observation period. Precipitation amount, intensity and temporal distribution control drainage volume and concentration control drainage volume and concentration in discharged water (Chatterjee, 2016). Nitrate concentrations were slightly lower under subsurface drained conditions than undrained conditions across different nitrogen application rates; this might be due to greater N uptake by sugarbeet crops under favorable growing condition Awale et al. (2015). Large variations in nitrate concentrations among replicates were likely caused by variability in soil properties that impacted water movement through profile and leaching below the sugarbeet root zone.

Awale, R., A. Chatterjee, H. Kandel, J.K. Ransom. 2015. Tile drainage and nitrogen fertilizer management influences on nitrogen availability, losses, and crop yields. Open Journal of Soil Science, 5:211-226.

Chatterjee, A. 2016. Soil and fertilizer management practices to control nutrient losses under subsurface tile-drained conditions. In: Soil Fertility Management in Agroecosystem, Chatterjee, and Clay (Eds.), p. 124-133, ASA-CSSA-SSSA, Madison, WA.

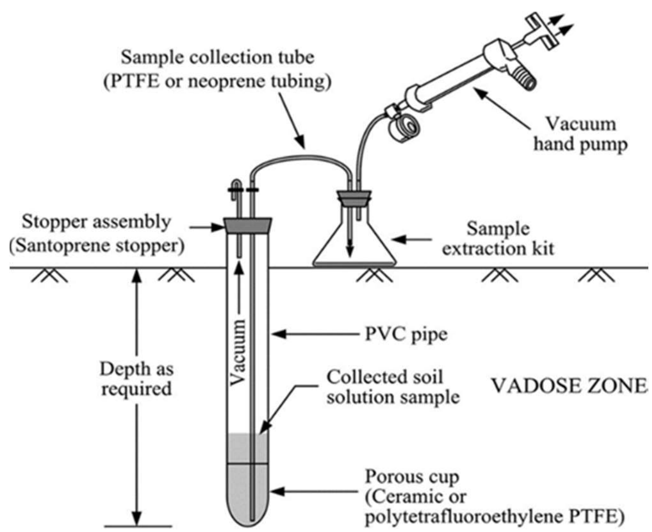
Jabro, J.D., W.B. Stevens, W.M. Iversen, B.L. Allen, and U.M. Sainju. 2016. Suction cup samplers for estimating nitrate-nitrogen in soil water in irrigate sugarbeet production. Journal of Environmental Protection, 7:1342-1354.

Sebilo, M., B. Mayer, B. Nicolardot, G. Pinay, and A. Mariotti. 2013. Long-term fate of nitrate fertilizer in agricultural soils. PNAS 110(45):18185-18189.

Objectives:

1. Survey the seasonal average nitrate leaching under tile-drained fields under sugarbeet production
2. Relationship between nitrate leaching with soil type, fertilizer-nitrogen management, and rainfall
3. Relationship between soil available nitrogen balance (soil profile nitrogen difference between after planting and harvest) and sugarbeet yield and quality under tile-drained fields

Materials and methods:



Ten participatory growers' fields, with tile drain and planted to sugarbeet in 2018, will be selected for this study. After planting, four suction cup lysimeter, 10 ft apart, will be installed at 4 ft soil depth. Suction cup will be subjected to a continuous vacuum of 0.04 MPa. Initial and after harvest, soil samples with 0-6, 6-24-24-48" depth increments will be collected using a hydraulic probe for nitrate-nitrogen concentration. Throughout the growing season, water samples will be collected from the suction tubes once a week and will be continued until the harvest. Nitrate concentration will be determined conductimetrically following reduction to ammonia. Seasonal average nitrate concentration in soil water (CN) for each site will be calculated as CN=$\sum_i^n CN_{i/n}$, i=1, 2…..n that corresponds to sampling event.

Sugarbeet will be hand-harvest to determine the yield and quality. Crop rotation, soil classification, rainfall, soil moisture and temperature, fertilizer application rate information will be collected for each site.

Timeline of anticipated accomplishments

Field identification, initial soil sampling, lysimeter installation	May 2018
Water sampling and nitrate analyses	May-Aug. 2018
Sugarbeet harvest and post-harvest soil sampling	Sept.-Oct. 2018

Budget

Labor: Graduate student salary+3% Fringe Benefit	\$8,000+\$240= \$8,240
Travel (100 miles×10 trips×10 sites×\$0.50)	\$5,000
Supplies: Suction cup lysimeter (10 site×4 rep×\$40/unit)	\$1,600
Analyses: (10 sites×4 rep× 20 (soil & Water) samples ×\$2.50)	\$2,000
Total	\$16,840

3. Project Title: Adopting Cover Crops in Sugarbeet Production System

Project Description (New): Different types of fall seeded and inter-seeded cover crops on sugarbeet production will be evaluated based on their effect on sugarbeet yield and quality and cover crop biomass production

Project Leader:

Amitava Chatterjee (PI)- Soil Science, NDSU, Fargo, ND

Marisol Berti (Co-PI)- Plant Science, NDSU, Fargo, ND

Other personnel involved: Norman Cattanach – Soil Science, NDSU, Fargo, ND

Project Location: Prosper and Hickson, North Dakota

Justification of Research: Quick-growing cover crops hold soil in place, reduce crusting and protect against erosion due to wind and rain. The aboveground portion of cover also helps protect soil from the impact of raindrops. Long-term use of cover crops increases water infiltration and reduces run off that can carry soil and nutrients away. These late-summer or fall-planted crops often put on significant growth even when temperature drop into the 50s. By slowing erosion and runoff, cover crops can reduce nonpoint source pollution.

Summary of Literature Review: Conventional tillage practices in sugarbeet production in North Dakota and Minnesota reduce or eliminate surface plant residue which increases the potential for wind erosion. Seeding sugarbeet into living cover crops will reduce soil erosion and may prevent stand loss due to strong spring winds. Stordahl (1991) concluded sugarbeet were successfully produced utilizing living cover crops on a Bearden loam soil at Casselton, but early control of the cover crop was imperative. Cattanach and Overstreet (2010) also found spring seeded cover crops resulted in greater plants per 100 ft of crop row at harvest. These crops were also observed to have greater seedling emergence after planting, perhaps as a result of breaking the soil crust ahead of the sugarbeet seedlings in the spring. Fall rye + pea was very good fall seeded cover crops.

Cattanach, N.R., and L. Overstreet. 2010. The evaluation of cover crops on yield and quality of sugarbeet. 2009 Sugarbeet Research and Extension Reports, Vol. 40: 129-131.

Stordahl, J.B., A. G. Dexter, and A.W. Cattanach. Production of sugarbeet in living cover crops. 1990 Sugarbeet Research and Extension Reports, Vol 21: 213-215.

Objectives:

1. Effect of five fall seeded cover crops, (i) winter wheat, (ii) winter rye (*Secale cereale* L.) cv. ND Dylan, (iii) winter camelina, (iv) oat, and (v) radish on sugarbeet yield and quality and soil nitrogen availability with and without fertilizer N
2. Effect of seeding time and different inter-seed cover crops, (i) winter rye (*Secale cereale* L.) cv. ND Dylan, (ii) winter camelina (*Camelina sativa* L.) cv. Joelle, (iii) winter Austrian pea (*Pisum sativum* L.), and (iv) white mustard (*Sinapis alba* L.) cv. Kodiak on sugarbeet yield and quality and cover crop biomass production

Materials and Methods:

<u>Fall-seeded cover crops</u>- This field experiment will be conducted at Hickson and Prosper. Field experiment is laid out in a randomized complete block design with a split-plot arrangement with six cover crop treatments as the main plot and nitrogen fertilizer (with and without) as sub plot with four replicates. Five cover species, (i) winter wheat, (ii) winter rye (iii) winter camelina, (iv) oat, (v) Daikon radish and without cover crop (check) were planted in fall 2017 on wheat residue. In spring 2018, nitrogen fertilizer will be broadcasted and incorporated. Sugarbeet will be planted on the cover crop residue. Soil available nitrogen from 0-6", 6-24" and 24-48" depths will be collected throughout the season. Surface (0-6") soil water content will also be recorded using data logger. The middle two rows of each plot will be harvested and subsample will be analyzed for quality parameters.

<u>Inter-seeded cover crops</u>- This field experiment will be conducted at Ada and Sabin. Field experiment will be laid out in split plot with five cover crop treatments, (i) check (no cover crop), (ii) winter rye, (iii) winter camelina, (iv) winter Austrian pea, (v) mustard, as main plot and two cover crop planting time (end of July and end of Aug.) as sub plot with four replications. Recommended NPK fertilizers will be applied and incorporated. Standard sugarbeet cultivar will be planted. Cover crops will be inter-seeded in between sugarbeet rows using a hoe. Middle two rows of each plot will be harvested and subsample will be analyzed for quality parameters. After beet harvest, soil available nitrogen will be determined for 0-6" 6-24" and 24-48" depths. Soil moisture content will be recorded since cover crop planting until November. Cover crop biomass will be measured at the end of the season. At the end of the season, soil available nitrogen will be determined for 0-6" and 6-24" depth.

Timeline of anticipated accomplishments

1. Planting of fall-seeded cover crops	Fall 2017
2. Initial soil test	Spring 2018
3. Fertilizer application and sugarbeet planting	Spring 2018
4. Cover crop planting	July and Aug. 2018
5. Soil sampling and nitrogen analyses	Summer 2018
6. Sugarbeet harvest	Fall 2018
7. Cover crop biomass measurement	Fall 2018

Budget:

Dr. Chatterjee	
Labor: Technician salary (for 2 month)+42% fringe benefit	8,000+3,360= $11,360
Labor: undergraduate students ($14/hr×20 hr/wk×4 wk)+10% Fringe	1120+112= $1,232
Soil sample analyses (88 plots×3 depths×4 times×2 sites×$3.00/sample)	$6,336
Travel (100 mile round trip×2 sites×10 trips×$0.74/mile)	$1,480
Land rent ($400/ac×2 sites)	$800
Dr. Berti	
Technician Salary (for 1 month)+48% Fringe	3,333+1,599=$ 4,932
Total	$26,140

4. Sugar beet Planter Test Stand Clinics

Project Description:

Sugar beet planter test stand clinics are held each year at 22 locations in the Red River Valley, Southern MN, and Eastern MT. Test stand clinics offer sugar beet growers the opportunity to evaluate their sugar beet planters and identify problems before they result in crop yield loss.

Project Leader:

Norman Cattanach – Soil Science, NDSU, 701-793-8184

Amitava Chatterjee-, Soil Science, NDSU, 701-231-7858

Project Location:

22 locations throughout the Red River Valley, Southern Minnesota, and Eastern Montana

Justification for Research: Sugar beet planter test stand clinics have been an important part of pre-season field preparations of sugar beet farmers for 30 years. Dr. Joe Giles initiated the sugar beet test stand clinics in 1984 with the help of Norman Cattanach. Every year from late February through early April, test stand clinics are held at 17 locations in eastern Montana, throughout the Red River Valley, and in Southern MN. Planter maintenance is a critical factor in optimizing plant establishment with high seed cost. Research and time-tested experience indicate that high stand establishment is the most critical component in producing good yields and high sugar content. Accuracy of seed placement, which is a key factor in stand establishment, is evaluated and optimized at the sugar beet planter test stand clinics. During the planter test stand clinics, growers can discover defective planter parts and receive help repairing them. Additionally, growers can compare coated seed and pellets of different sizes, match planter plates to seed size used, evaluate vacuum settings, and get information from planter experts, seed dealers, agronomists and other growers.

From the inception of the test stand clinics, Norm has independently organized locations, dates, transportation issues, and the necessary assistance. Organizing the clinics is a major undertaking each year, requiring coordination with agronomists and machinery dealerships at each clinic location to confirm dates, adequate facilities, and sufficient advertisement. Norm attends most of the test stand clinics personally to operate the stands, trouble shoot problems with planters, and provide expert advice to growers.

Objectives: Assist growers in maintaining and correcting sugar beet planter units to obtain optimal operation for seeding activities

Materials and Methods: Clinics were held at 17 different locations in the spring of 2016. Length of stay at each location was 2-4 days. The test stand schedule begins in late February and ends the first part of April. Request for funding includes travel for vehicles to transport equipment to the locations, updating/maintaining the test stands and equipment, and technician support.

Time Line of Anticipated Accomplishments:

The continued interest of growers for this service will determine the timeline of this project.

Budget:

Items	Cost
Technician Salary	$27,000
Fringes@42%	$11,340
Supplies & Repair	$5,500
Travel	
Mileage ($0.74/ mile*1036 miles(roundtrip)*10 sites* 2 times)	$15,332
Vehicle Depreciation cost ($167*4 months)	$668.00
	$16,000
Total	$59,840

Cumulative Budget

Items	Project 1	Project 2	Project 3 (Chatterjee)	Project 3 (Berti)	Project 4	Total
Technician	$4,000		$8,000	$3,333	$27,000	$42,333
Fringe	$1,680		$3,360	$1,599	$11,340	$17,979
Graduate		$8,000				$8,000
Fringe		$240				$240
Undergraduate	$1,120		$1,120			$2,240
Fringe	$112		$112			$224
Supplies	$1,500	$1,600			5,500	$8,600
Travel	$1000	$5,000	$1,480		$15,332	$22,812
Rent	$800		$800			$1,600
Fees		$2,000	$6,336		$668	$9,004
Total	$10,212	$16,840	$21,208	$4,932	$59,840	$113,032