Northern NY Agricultural Development Program
Project Report

Soil Sampling for Agronomic and Environmental Risk Assessments in Zone-Based Management in the Era of Technology

Project Leader:

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Collaborators:

- Crop Consultants and Nutrient Management Planners: Mike Contessa and Eric Beaver, Champlain Valley Agronomics, Peru, NY
- Cornell Cooperative Extension: NNY Regional Field Crops Specialists Kitty O'Neil, Ph.D., Mike Hunter
- Cornell University Campus/NMSP: Crop Yield Data Analyst Manuel Marcaida III, Undergraduate Research Assistant Celia Walden
- Northern New York dairy producers (4).

Background:

Soil testing is essential for determining if additional fertilizer, manure, or lime is likely to increase yield and crop quality. Cornell University nutrient management guidelines for field crops take into account soil pH and buffer capacity of the soil for lime determination, and nutrient availability in the soil, soil type, crop rotation, and past manure management practices for fertility management.

Traditionally, it has been recommended to sample fields at least once in three years, combining sufficient number of cores into one sample that should not represent more than one field or 15 acres. Research conducted about 10 years ago in central New York showed that, for most reliable estimates, the equivalent of 2-3 or more subsamples per acre should be taken. What this means is that for the most reliable results, you multiply the size of the field in acres times 2 or 3 to know how many cores to take and combine into one sample that represents the field.

Yield monitor technology now allows farmers to document yield at the within-field scale and a growing number of farmers now have sufficient years of yield data to create yield stability-based zone maps (see Figure 1 for an example). A growing number of farmers is asking questions about drivers for yield stability. In other words, what causes some areas within fields and fields within a farm to consistently produce higher yields than other areas, and what causes other areas to be incredibly variable in yield from year to year. Soil sampling can help understand zone-to-zone differences, and hence guide within-field crop management, but **zone-based sampling protocols need to be developed**.

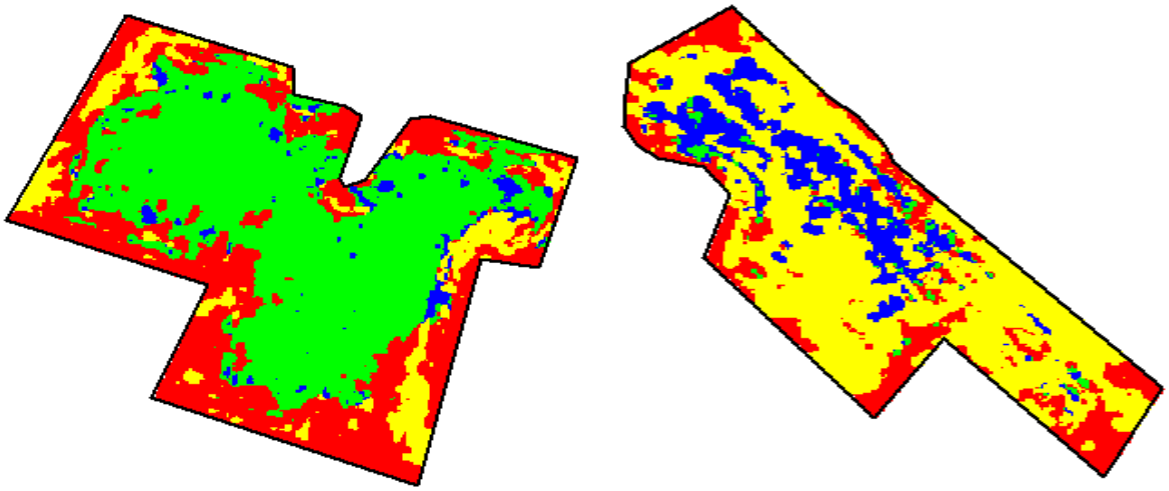

Figure 1: Yield stability maps for two fields that show consistently high yielding areas (green), consistently low yielding areas (red), areas that are high yielding but variable yielding over time (blue) and areas that are low and variable yielding over time (yellow).

Traditionally, we use wet chemistry to determine soil fertility parameters and pH, but that information is limited to the number of soil cores we take. However, some consulting firms now have technology to obtain a subset of soil fertility and quality indicators with "on-the-go" equipment. This includes Veris Technology that allows for determination of pH, organic matter, cation exchange capacity (CEC), and electrical conductivity (EC) on the go, at much higher intensities than can be done with soil sampling. These type of technologies for soil mapping, combined with use of digital elevation maps, satellite imagery, crop sensors, and grid sampling for other soil parameters may allow for better understanding of drivers of yield and yield stability and development of more efficient and meaningful field sampling and crop management strategies over time.

Methods:

We worked with northern New York farmers who supplied corn grain data (1), corn silage data (1), or both corn silage and grain data (1) (Table 1). Each farm had at least four years of yield data to derive multi-year corn yield reports (data through 2021) and yield stability zones. Yield mapping was done by determining the whole farm average yield and average standard deviation in yield (variability) over years, and the classifying every 6x6-feet grid cell as Quadrant 1, 2, 3, or 4.

Areas classified as Q1 (green) are consistently yielding above the whole farm average. The Q4 areas (red) are consistently yielding below the whole farm average. Areas in Q2 and Q3 are variable in yield over years (high temporal yield variability) with, on average, yields below the whole farm average for Q3 and above the whole field average in Q4. Yield stability zone maps were derived for four corn grain and four corn silage fields.

Each field was mapped for pH, EC, slope, and altitude using a Veris unit (Table 1) and grid-sampled at a 0.5-acre grid size after harvest in fall 2021. The grain fields were additionally mapped for buffer pH, organic matter, and CEC.

Grid soil samples were taken (0-8 inches) and shipped to the Analytical Laboratory and Maine Soil Testing Service for analyses of soil fertility parameters using the Cornell Morgan extraction.

Per field, for each zone, we determined the mean, standard deviation, and quantiles of each soil parameter (Part A), and then used machine learning technologies to determine which soil or landscape parameters best explained variability in zones within each field (Part B).

Table 1: Complete list of fields analyzed with the corresponding Veris data from each field; Zone-Based Management project, NNYADP, 2021.

Farm	Field	Yield Type	pH	Buffer pH	EC	CEC	OM	Altitude	Slope
A	A1	Silage	□		□			□	□
	A2	Silage	□		□			□	□
B	B1	Grain	□	□	□	□	□	□	□
	B2	Grain	□		□	□	□	□	□
	B3	Silage	□		□			□	□
	B4	Silage	□		□			□	□
C	C1	Grain	□	□	□	□	□	□	□
	C2	Grain	□	□	□	□	□	□	□

The Boruta model was used to identify the main drivers of yield and yield stability based on Veris-derived features. To be consistent with the 6x6-ft grid size of the yield stability maps, the Veris soil maps were kriged (a geostatistical interpolation technique) using the same resolution. The Boruta method ranks the soil measurements according to level of importance in terms of contribution to yield. Models were run for each farm and crop yield type listed in Table 1, using data collected to date (this excluded grid sample results; those will be included once data are received from the laboratory).

Preliminary Results:

Characterization of Yield Stability Zones

Yield stability box plots showed the higher yields in Q1 and Q2 compared for Q3 and Q4 for four farm datasets in the study (Figure 2).

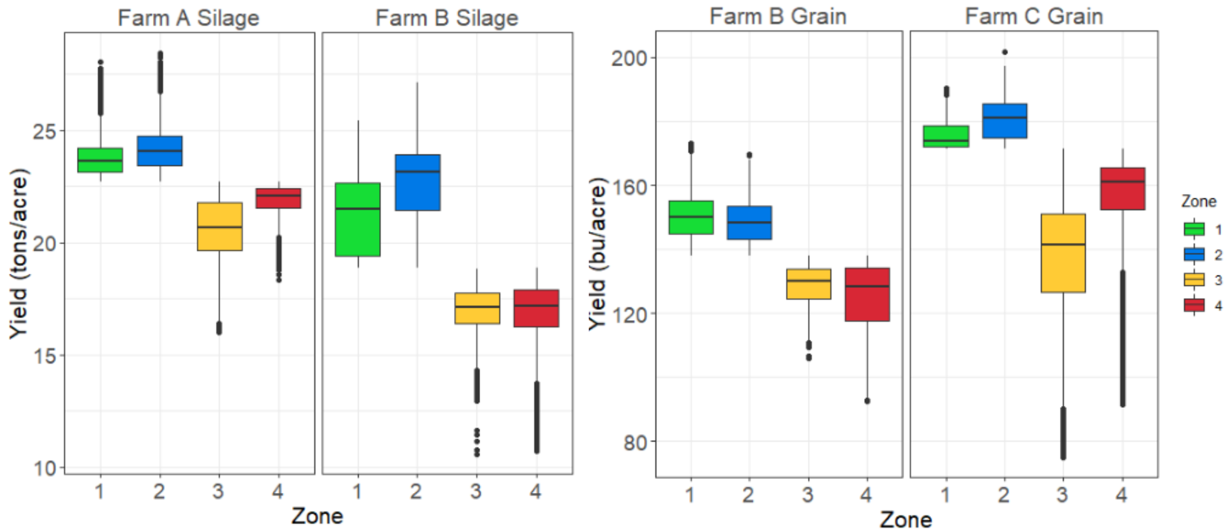

Figure 2: Zone-based yield boxplot of the sample farms according to crop type (silage on the left, grain on the right); Zone-Based Management project, NNYADP, 2021.

Most fields had at least 2-3 yield stability zones represented. An example is shown in Figure 3. For this grain field, yield in Q1 and Q2 were both 163 and 165 bu/acre versus 113 and 140 bu/acre for Q3 and Q4, respectively. For this specific field the lowest yielding quadrant had the lowest OM levels (4.9% versus 5.9, 5.9, and 5.4% in Q1, Q2, and Q4) but highest pH, buffer pH, EC and CEC. Difference occurred from field to field and farm to farm and the additional data layers are needed to complete the evaluation.

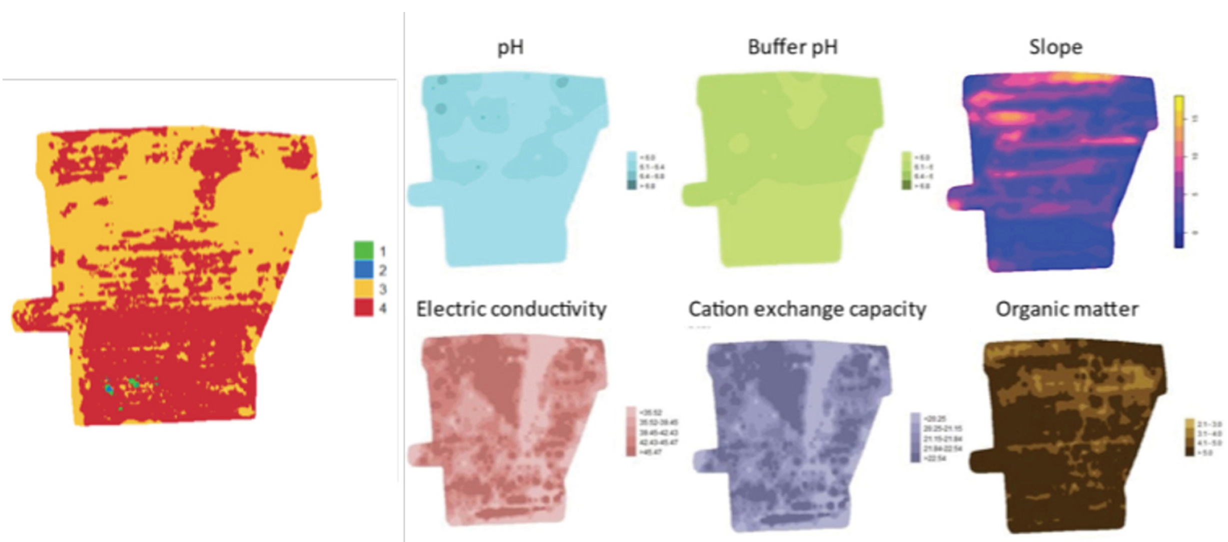

Figure 3: Example of a zone map (left), and Veris-derived pH, buffer pH, slope, electric conductivity (EC), cation exchange capacity (CEC), and organic matter maps.

Drivers for Yield and Yield Stability

Model results showed that all the Veris-generated data (pH, buffer pH, EC, CEC, OM, slope and altitude) were considered important (Figure 4). Across fields, among the top-ranking features were altitude, slope, organic matter, and pH. Box plot figures showed average pH for each of the quadrants for each farm and crop type, suggesting higher yields with higher pH for the two farms that supplied grain yield data (Figure 5). Additional analyses will be done once grid sample results are obtained. Landscape classification will also be included since slope and altitude were consistently classified as important drivers.

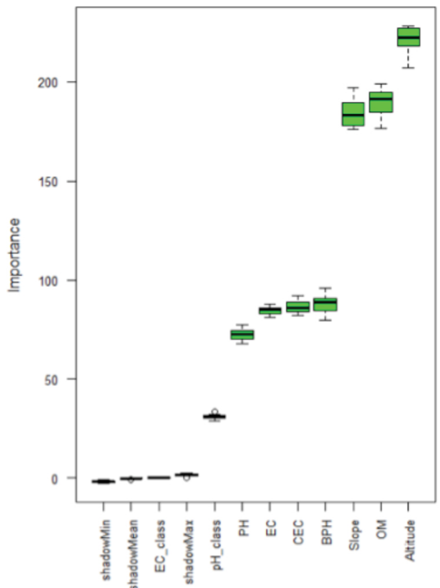

Figure 4: Sample analyses plots for grain yield showing the Boruta importance ranking of the Veris soil features for one field; Zone-Based Management project, NNYADP, 2021.

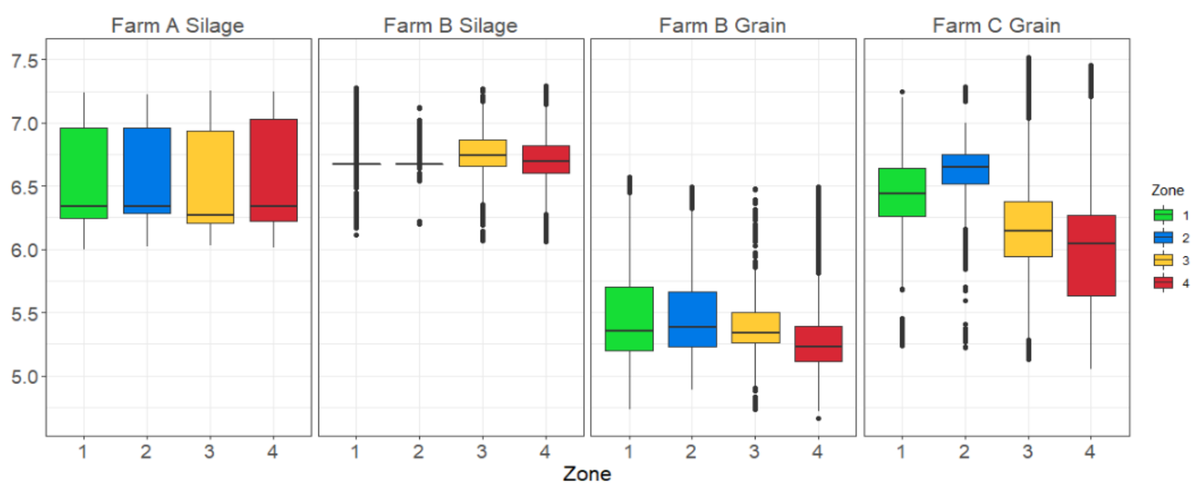

Figure 5: Zone-based boxplots of pH values on each sample farm and crop type; Zone-Based Management project, NNYADP, 2021.

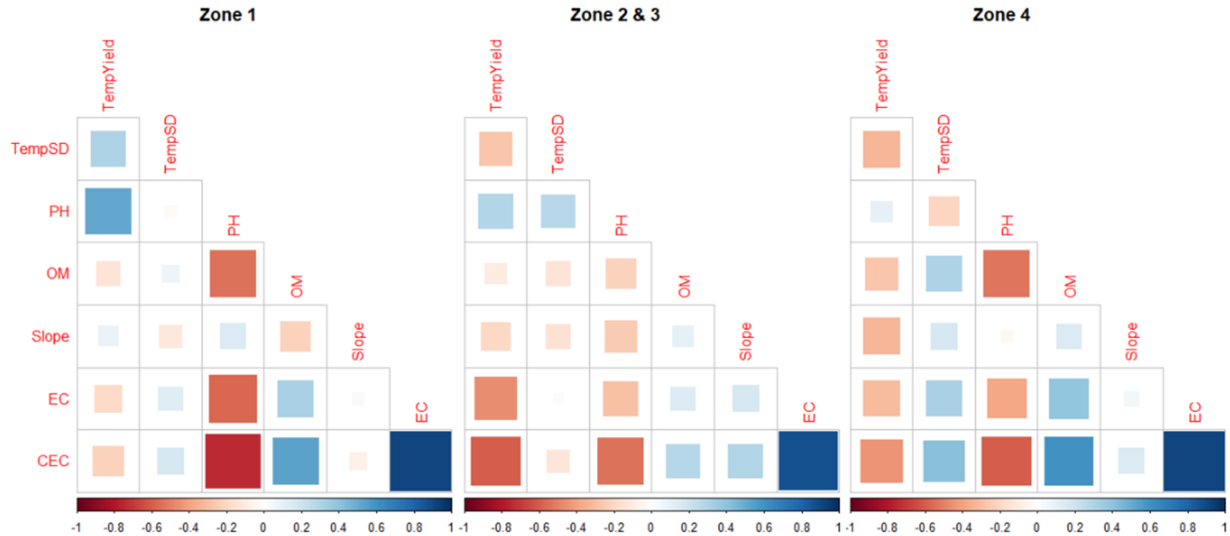

Figure 6: Sample per zone correlation plots of the important features identified by the Boruta model. Note that variable zones (Zones 2 and 3) were combined for the correlation analysis; Zone-Based Management project, NNYADP, 2021.

After the important features were identified, a correlation matrix was created per zone (Figure 6) to further examine the relationships among variables. Degree of correlation changed by zone. For instance, temporal yield was highly and positively correlated with pH in Zone 1, but its importance diminishes in lower-yielding zones. The correlation matrix is also useful in verifying the relationships between individual Veris soil measurements. Using the same sample farm in Figure 2, organic matter was positively correlated with EC for both Zone 1 and Zone 4. This implies that EC is an indicator of organic matter.

Conclusions/Outcomes/Impacts:

Initial results based on this trial of Veris mapping of four northern New York farm fields suggest that all soil features included in the analyses (pH, EC, CEC, organic matter, slope, and altitude) are important, but ranking varied according to field and yield type. In most cases, slope, altitude, and pH were the top drivers for yield. Once landform, NDVI (normalized difference vegetation index), and grid sample results are included, expanded and enhanced analysis will be done.

Outreach:

- Each of the participating farms received their yield stability zone maps for all fields with at least three years of data. Work is ongoing and individual farm reports will be generated once laboratory analyses can be included and more complete models are run.
- At the request of consulting firms, we developed a new Agronomy Factsheet to address grid soil sampling as applied to the New York Phosphorus Index 2.0:
  - Agronomy Factsheet #117: How to Use Grid Soil Sample Results for the NY-PI 2.0; http://nmsp.cals.cornell.edu/publications/factsheets/factsheet117.pdf.
- Student participation: This study is the honors thesis of a Cornell University undergraduate student in Biometry and Statistics, who will graduate in May of 2022. Our summer interns and NMSP staff traveled to northern NY and visited with Mike Contessa and Eric Beaver of Champlain Valley Agronomics and Laura Klaiber and Allen Wilder of the Miner Institute. At the Champlain Valley Ag stop, they learned about crop consulting and precision agriculture.

Next Steps:

The findings from the northern New York farms will be combined with findings from farms in central and western New York to add to statewide knowledge base. Work is ongoing to gather a larger dataset with both Veris and grid sample results for all fields in the project.

Acknowledgments:

We thank the farmers participating in the project for sharing data and providing valuable feedback on findings and scenarios to evaluate.

For further information, contact:

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Photos:

Photo 1: The Zone-Based Management project team with Mike Contessa (left) of Champlain Valley Agronomics and Miner Institute Research Scientist Laura Klaiber (right) discussing field and within-field management of nutrients. Photo: Allen Wilder.

Photo 2: Mike Contessa of Champlain Valley Agronomics talks about precision agriculture and Veris mapping of fields for electric conductivity, organic matter, pH, and cation exchange capacity with members of the Zone-Based Management project team. Photo: Quirine Ketterings.