Northern New York Agricultural Development Program
2024 Project Report

Development of a User-Friendly Web-Based Tool for Farmers to Implement and Analyze On-Farm Research

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Collaborators:

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- Miner Institute: Allen Wilder, Forage Agronomist
- Campus Collaborators: Subhashree N. Srinivasagan, Manuel Marcaida (NMSP)
- Four Northern New York farms.

Background:

On-farm research has proven to be an effective method for evaluating management practices, including fertilizer application, plant population, and fungicide use in real-world conditions. By conducting trials on-farm, the results gain credibility with the farmers, increasing the likelihood of adoption of management changes across the entire farm.

Randomized complete block designs (strip trials), often used in on-farm research, are effective but such designs are space-intensive, can disrupt farming operations, and require multiple replications to achieve statistical significance. Advances in agricultural technology, particularly yield monitor sensors, have created an opportunity to addressed these challenges. Yield monitors record crop yields in real-time during harvest, enabling the development of multi-year yield stability zone maps. These maps categorize fields into four zones: high-yielding and stable (Q1), high-yielding and variable (Q2), low-yielding and variable (Q3), and low-yielding and stable (Q4), providing insights into spatial and temporal variability. This development allows findings to be extrapolated beyond the trial field. The Single-Strip Spatial Evaluation Approach (SSEA) was developed as a simplified, farmer-friendly alternative which uses yield monitor data and yield stability zone maps (Cho et al., 2021). The SSEA involves a single treatment strip in the field, implemented with the harvest direction, compared to the rest of the field using spatial yield data. The method's simplicity and reduced field disruption encourage wider adoption by farmers.

Until the inception of this project, SSEA analyses have been conducted manually, generating reports that include confidence charts, a critical tool for evaluating the economic viability and yield impact of treatments. Developing a web-based SSEA tool was essential to streamline analysis, automate confidence chart generation, and enable broader adoption. Coupled with implementing SSEA strips in collaboration with farmers, these advancements in agricultural technology can transform on-farm research, fostering data-driven decision-making and enhancing the efficiency of agricultural management practices.

The objectives of this project were to:

- develop a user-friendly web-based tool for automating SSEA analysis and confidence chart generation,
- develop an instruction document (user's manual), and
- work with farms to evaluate its use.

Methods and Results:

Collaborative planning and framework development

An advisory committee consisting of farm managers and consultants from across New York state, including northern NY, was established to help develop visuals and a user-friendly reporting system. The committee collaborated to identify the key requirements for the tool, which included enabling users to independently conduct analyses, interpret the results, and generate reports. Through extensive discussions, the committee proposed a user-friendly approach to interpreting the SSEA results that included a "confidence chart," which visually represents the likelihood of yield benefits or losses across different yield stability zones caused by treatments applied in the single-strip. Yield benefits or losses are shown in ranges (0.25 tons/acre increments and decrements for corn silage and 3 bu/acre increments and decrements for corn grain).

Additionally, a figure comparing the overall field's yield stability zones with those in the control and treatment strips was finalized. This feature was included to provide users with a clear picture of the major zones (green, blue, yellow and red) that the single strip evaluated.

To ensure accessibility, it was decided to develop the tool on an open-source platform, allowing users to freely access and use it. The framework for the tool was developed and presented at farmer and extension meetings to gather feedback. The primary goal was to create a user-friendly SSEA webtool that could visualize user inputs, generate results, and provide downloadable figures and reports with automated interpretations.

Development of the SSEA webtool

The SSEA webtool was developed using open-source Shiny R, a powerful framework for building interactive web applications. Shiny applications consist of two main components: the user interface (UI) and server logic, which work together to provide a seamless, intuitive, and responsive user experience (Figure 1). The UI is designed to ensure user-friendliness, keeping the target audience of farmers, farm managers, and consultants in mind. The server component manages the tool's backend, housing the algorithms and analytical workflows necessary for running spatial models, generating visual outputs, auto-generated results, and downloadable report. It processes user inputs from the UI, feeds them into spatial models, and computes the results.

The SSEA webtool is organized into four main tab. The *"Inputs & Analysis"* tab allows users to specify the location of single strips, upload yield monitor data, yield stability zone maps, and average temporal yield (Figure 2). It includes a visualization feature that displays uploaded files on a base satellite map layer with the respective legends appearing on the top right corner. Users can zoom in, pan, and overlay data layers as needed, offering flexibility and clarity in viewing field data. Additional information about the treatment (optional) can be also provided in this tab.

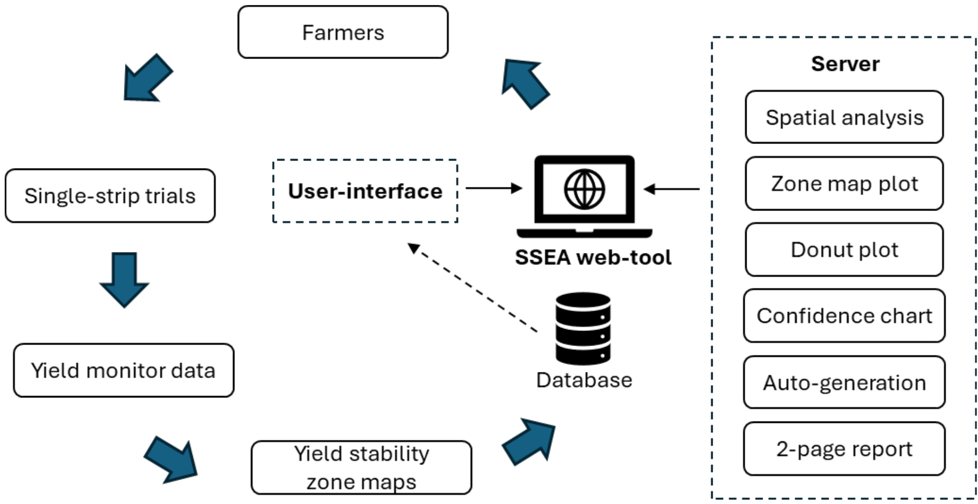


Figure 1. System architecture and structure of the single-strip spatial evaluation analysis webtool.

The *"Results"* section displays key outputs, including spatial analysis results displayed as confidence charts.

The *"Report"* tab provides editable auto-generated inferences based on the results. These reports are editable directly within the webtool and can be downloaded as PDF documents for record-keeping or further sharing.

A detailed user's manual was developed and this document is included in the *"About"* tab, which also offers troubleshooting tips and result interpretation.
The key features of this tool include interactive visualization and automated reports. The tool offers dynamic map-based visualizations, enhancing the interpretation of spatial data. The webtool automatically generates inferences and downloadable reports. This feature streamlines reporting, saving time for users while ensuring accuracy.

The tool underwent rigorous performance testing to evaluate its ability to handle large datasets and simultaneous users. During testing, the webtool successfully supported up to fifteen concurrent users, demonstrating its robustness and scalability for real-world applications.

Case study: Using the SSEA tool

For 2023 and 2024, yield monitor data for 6,127 acres were obtained, cleaned, and processed for field yield reporting and yield stability zone mapping, with data cleaning for 2024 for eight more northern NY farms still ongoing. The SSEA trials conducted in 2023/2024 included strips testing the impact of manure application, with comparisons between strips with manure and those without. These trials were used to evaluate the entire process from placement of the strip in a field through the reporting of the findings to the farm. The case study in this report, analyzed a 35 acre northern NY field with manure as the treatment using the SSEA tool.

Data input and analysis

The strip trial data, along with other necessary inputs such as the yield stability zone map, current yield monitor data, and kriged yield (estimated) for calculating the temporal average yield, were uploaded to the webtool's user interface (Figure 2). These inputs are essential for running the spatial model analysis. Based on selected checkboxes, the inputs were displayed on the base map. Figure 2 illustrates an example of strip location overlaid on the yield stability zone map. Optional inputs such as the treatment details were added to the webtool using the flip panel, accessible by clicking "Edit Input/Details." Once all required data were entered, the "Run SSEA Analysis" button was used to process the information through the spatial model, generating results, visualizations, and inferences.

Tool results development

The SSEA results were generated by the algorithm for SSEA in the server. The Results section includes two key result figures. The first is the donut plot (Figure 3a) that visualizes the distribution of zones in the field compared to those within the strips (control and treatment), and the outer ring represents the zones across the entire field, while the inner ring shows the zones within the strips, allowing for an assessment of whether the strips are representative of the field's zones. The plot also provides details on the total field area and the portion occupied by the strips. The "qualified zones" indicate the zones that meet the criteria for spatial analysis. In this case study, the high-yielding zone (Q1) is predominant, covering 90% of the field and 95% of the strips, with other zones being minimal.

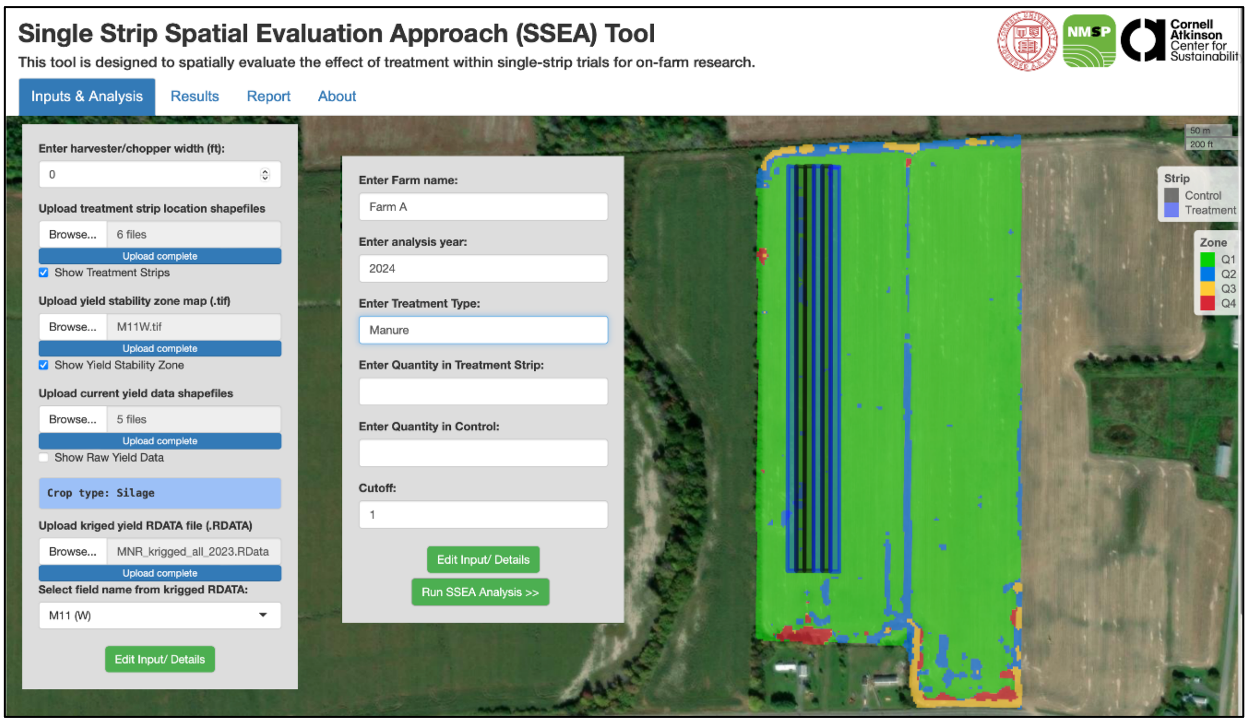
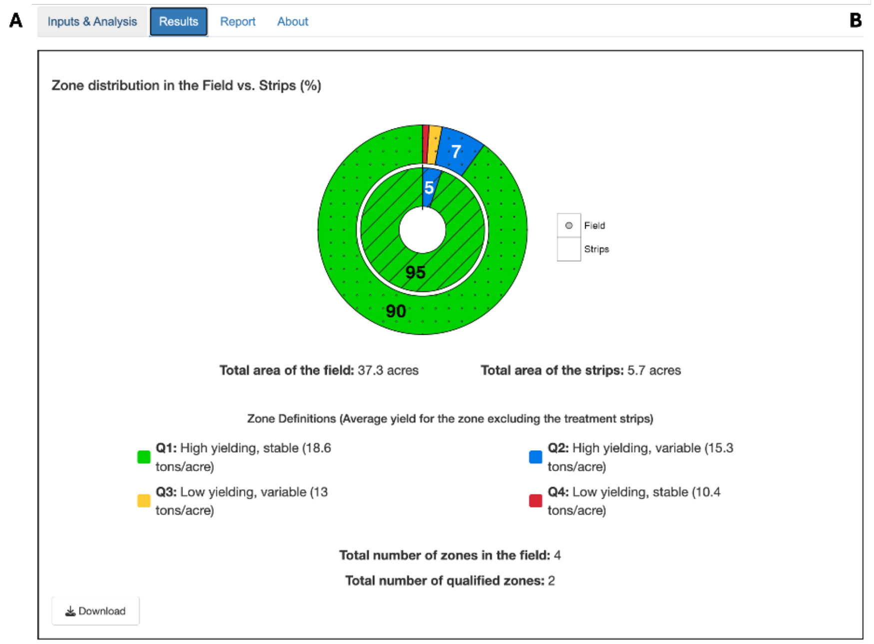


Figure 2. Overview of the SSEA webtool's user interface, highlighting the user inputs provided to the tool and the visualization of these inputs. The image displays the uploaded manure treatment strip locations overlaid on the yield stability zone map.

The second key result figure in the report, the confidence chart (Figure 3b), is the primary output of the single-strip spatial analysis. It depicts the confidence level of yield outcomes, either as a benefit or a loss, resulting from the treatment applied in the single strip. In this case study, the application of manure demonstrated a high confidence of yield benefit in zone Q1 (high-yielding and stable), with an increase of up to 2.25 tons/acre. Zone Q2 (high-yielding but variable) is not considered significant due to insufficient data (only one spatial point). Both the donut plot and the confidence chart can be downloaded as PNG files using the "Download" button. The results generated by the tool align closely with those obtained manually using an R programming script, demonstrating the reliability of the tool's outputs.



B

	Yield response (tons/acre)	Q1 (%)	Q2 (%)	Q3 (%)	Q4 (%)
	Spatial points	535	1	0	0
Benefit	≥5	1	74	NA	NA
	4.75 — 5	1	77	NA	NA
	4.5 — 4.75	3	80	NA	NA
	4.25 — 4.5	5	83	NA	NA
	4 — 4.25	9	85	NA	NA
	3.75 — 4	14	88	NA	NA
	3.5 — 3.75	22	90	NA	NA
	3.25 — 3.5	31	92	NA	NA
	3 — 3.25	42	93	NA	NA
	2.75 — 3	54	94	NA	NA
	2.5 — 2.75	65	95	NA	NA
	2.25 — 2.5	75	96	NA	NA
	2 — 2.25	84	97	NA	NA
	1.75 — 2	90	98	NA	NA
	1.5 — 1.75	94	98	NA	NA
	1.25 — 1.5	97	99	NA	NA
	1 — 1.25	98	99	NA	NA
	0.75 — 1	99	99	NA	NA
	0.5 — 0.75	100	99	NA	NA
	0.25 — 0.5	100	100	NA	NA
	≥0	100	100	NA	NA

High (81%-100%) Somewhat (61%-80%) Neutral (41%-60%) Low (21%-40%) Not Confident (0%-20%)

Figure 3. The "Results" tab displays (a) donut plot with the yield stability zone distribution; and (b) a confidence chart indicating the likelihood of yield benefit or loss resulting from the implemented manure treatment. Here the results show great benefit of use of manure for yield in the higher yielding zones.

SSEA Report

The "Report" section provides auto-generated conclusions based on the results. Each conclusion is displayed within an editable text box, allowing users to make modifications or add additional information as needed. The report summarizes the yield stability zone distribution results and conclusions drawn from the confidence chart. These auto-generated conclusions and result figures can be downloaded as PDF report using the "Download Report" button.

Conclusions:

The development and implementation of the SSEA webtool mark a significant step forward in advancing on-farm research and improving data-driven decision-making in agricultural management. By automating complex spatial analysis and streamlining reporting, the tool reduces the barriers associated with traditional research methods, making the process more accessible and user-friendly for farmers, farm managers, and consultants. The SSEA tool's ability to handle large datasets and support concurrent users highlights its scalability and readiness for broader adoption. Its open-source platform ensures accessibility, encouraging collaboration and widespread use. By facilitating the adoption of data-driven practices, the SSEA tool empowers farmers to make informed decisions, ultimately improving agricultural productivity and sustainability. The tool is now in the final steps of robustness evaluation and will be made available through links on the NMSP website in February/March 2025.

Outreach:

- Updated factsheet: Single-Strip Spatial Evaluation Approach. Agronomy Factsheet 124: http://nmsp.cals.cornell.edu/publications/factsheets/factsheet124.pdf.

- Ketterings, Q.M. (2024). Connecting the Dots: Dairy Sustainability, Value of Manure, Yield Stability Zones. NNYADP Research Update Meeting. Miner Institute, Chazy NY. March 13, 2024.

Next Steps:

Future efforts will focus on expanding adoption through ongoing collaborations with farmers and refining the tool based on user feedback, ensuring it remains a valuable resource for advancing precision agriculture. We also aim to develop a slideset on on-farm research that has instructions on how to implement a SSEA trial and interpret the results.

Acknowledgments:

We thank the northern New York farmers and crop consultants who shared yield monitor data with us and provided valuable feedback on the online trial evaluation tool and on earlier report drafts. Co-funding was obtained from USDA-NIFA (Federal Formula Funds) and the Atkinson Center for Sustainability.

Reference:

Cho, J. B., J. Guinness, T. Kharel, A. Maresma, K.J. Czymmek, J. van Aardt, and Q.M. Ketterings (2021). Proposed method for statistical analysis of on-farm single strip treatment trials. *Agronomy*, *11*(10), 2042.

For More Information:

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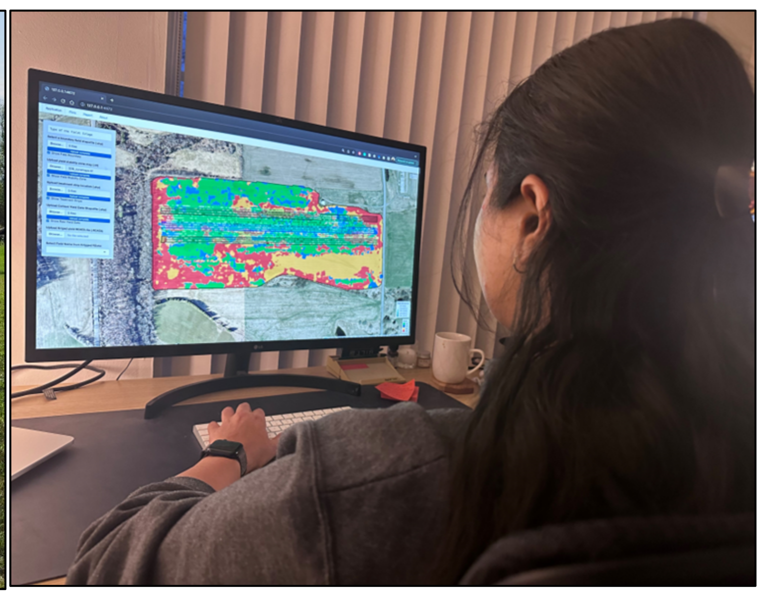
Photos:



Left: Field data collection from one of the SSEA trials in northern New York. Photo credit: Juan Carlos Ramos Tanchez, NMSP.

Right: Spatial analysis using the SSEA webtool. Photo credit: Subha Srinivasagan, NMSP.