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Prepared by David Clay

Achieving 100 Bu/A soybean yields: on-farm research and sharing high yield protocols with South Dakota soybean producers

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On-farm studies provide information that producers use to reduce the economic risks associated with new products, test the efficiency of components within their current operation, and test innovative new ideas and concepts. In the project, a producer chooses his/her treatments based on their interest or desire prior to implementation. SDSU agronomists assist in experimental design, treatment application, scouting, and analysis. At the completion of the project, reports are distributed to the farmer collaborator, and they are posted SD Soybean Research and Promotion on-farm web site. Farmers use results from the study to identify treatments that might be success on their farm and reduce the economic risks associated with new products. To date, over 450 experiments have been conducted by SD farmers. SDSU undergraduate students are using the on-farm studies for their capstone class and planning for SOY100 2022 is completed. We just received word that the American Ethanol Coalition and SDSU were funded in a UDSA-RCPP project focused on soil health. This project is centered around Madison, and it will provide funding for the adoption and quantification of BMP on soil health. We are in the process of identifying collaborators for this this on-farm study. This new project will help expand our on-farm research on soybeans and soil health.

1) Continue the on-farm research program in 2021;
    a. On farm studies
    b. Create a remote sensing yield model
2) Continue research designed to determine the importance of soil health in optimizing soybean
3) Deliver information to producers through Soy100, AgOutlook, SD on-farm web-site, news releases, radio interviews, and SDSU websites.
4) Use data collected in the on-farm SDSU classes (PS475 and PS428)

This year's research work involves two activities that include continuing the on-farm studies and creating a remote sensing based yield model.

1. Soybean On-farm Trials conducted in 2022:

Overall, we had over 79 total trials considering different yield zones throughout the state. This year trails were conducted at 18 different counties. Total enrollment was 30 growers including 15 new enrollments. On-farm research consist of varieties of experiment including seeding rate, varieties, Vitazyme, biologicals, fungicide et. This year's experiments are mostly dominated with

vitazyme, biological, seeding rate and soil health and UAV data was collected at different growth phase of the crop. More detail about the experiment is provided below in the table and figure.

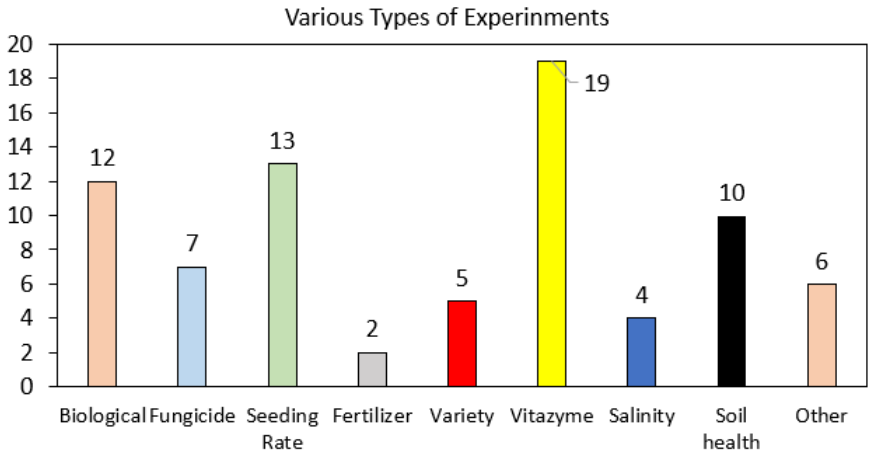
Table. Total list of the trail in 2022. Yellow color highlighted are new farmers enrolled in 2022.

Farmer	County	Treatment	# of Trials	UAV
Minor, Lance	Aurora	Vitazyme in-furrow	2	√
Minor, Lance	Aurora	GoldStart in-furrow	2	√
Minor, Lance	Aurora	Seeding rate reduced by 30k	2	√
Minor, Lance	Aurora	Seeding rate increased by 30k	2	√
Hamilton, Jeff	Beatle	compost	2	
Ostrem, Tim	Beresford	Vitazyme in-furrow	2	√
Hanten, Todd	Codington	Vitazyme in-furrow	2	√
Holzwarth, Luke	Codington	Vitazyme in-furrow	2	√
Strom, Nick	Groton	foliar fungicide	2	√
Martinmaas, Tyson	Highmore	foliar fungicides	2	√
Jorgensen, Bryan	Kimbell	Biological seed treatment	2	√
Jorgensen, Bryan	Kimbell	SG Assist - Starter	2	√
Jorgensen, Bryan	Kimbell	foliar micronutrient	2	√
Strom, Corey	Kimbell	Sound Ag foliar	2	√
Carlson, Scott	Kingsburry	Starter	2	√
Converse, Craig	Kingsburry	Vitazyme in-furrow	3	√
Alverson, Keith	Lake	Populations	3	√
Alverson, Keith	Lake	Varieties	3	√
Renaas, Doyle	Lake	Vitazyme seed treatment	2	
Loewe, Matt	Lincoln	low seeding rate	3	√
Loewe, Matt	Lincoln	high seeding rate	3	√
Dave Claussen	Miner	salinity	2	√
Scott, Kevin	Minnihaha	Vitazyme in-furrow	2	√
Harnisch, Matt	Mitchel	winter rye cover crop	2	√
Paul Westhoff	Salem	Different landscape	2	√
Fischbach, Chris	Warner	Sound Ag foliar	2	
Fischbach, Chris	Warner	Vitazyme foliar	2	
Fechner, Darren	Yankton	Vitazyme in-furrow	4	√
Van Osdel, Brandon	Yankton	foliar fungicide	2	√
Frank Nedved	Yankton	Variety	3	√
Chad Malone	Kingsbury	Soil Health	2	
Ed Wilkinson	Kingsbury	Soil Health	1	
Chad Malone	Kingsbury	Soil Health	1	
Greg Albrecht	Kingsbury	Soil Health	1	
Paul Casper	Kingsbury	Soil Health	1	
Paul Casper	Kingsbury	Soil Health	1	

Scott Jensen	Kingsbury	Soil Health	1
Jon Nelson	Kingsbury	Soil Health	1
Lynn Jensen	Kingsbury	Soil Health	1
Brett Anderson	Kingsbury	Soil Health	1

79

When compared to 2021-2022, the number of projects has increased from 63 to 71. Ten of these new on-farm projects are associated with soil health. The soil heath projects will be ongoing efforts over the next several years.



Total Farmers enrolled: 31

New farmers enrolled: 15

Total counties involved: 17

Figure 1. Various types of experinment conducted and their total numbers.

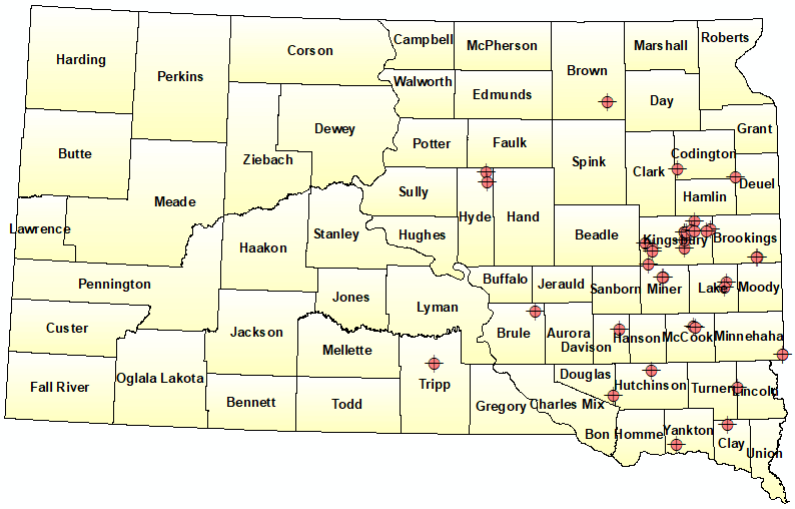


Figure 2. Distribution of different experinment at different counties of SD state.

Current progress

Abjective 1. Currently we have completed the project reports from 2022.

Objective 2: Develop PF algorithms that can be used by SD farmers to predict yields.

This has been completed and a summary of this work is below.

In modern precision agriculture, preharvest yield prediction plays a critical role in various decision-making process such grain policy making, crop marketing, price forecasting, insurance, and harvest plan. This paper presents deep neural network (DNN) as deep learning model and various machine learning based models such as random forest (RF), support vector machine (SVM), LASSO and ADABOOST in combination with high resolution satellite imagery to predict soybean yield in field scale level. Six high resolution satellite images (3.12 x 3.12m) at various growth stage of the soybean plants were used in 2019 and 2021 at three different locations of South Dakota. Ten different vegetative index (VI) were calculated from each derived images and yield data using yield monitoring system were used to predict soybean yield. Coefficient of determination (R2) and root mean squared error (RMSE) were utilized to evaluate the performance of models. Out of all tested models, DNN found to outperform to predict soybean yield across all locations and years. The reason behind its best accuracy was its multiple stacked nonlinear layers which resulted DNN as one of the most powerful nonlinear models. In our analysis we had 5 hidden layers and 50 neurons in each layer. Additionally, it applied cutting-edge deep learning methods like batch normalization and drop out, which improved overall prediction accuracy in comparison to other models. Moreover, accuracy of such model can be improved more by incorporating various environmental variables such as temperature, rainfall, soil type, elevation, and crop management in the models.

Objective 2: importance of cover crops

We conducted a detailed review article on the potential for cover crops to improve soil health. The abstract is below.

By influencing soil organic carbon (SOC), cover crops play a key role in shaping soil health and hence the system's long-term sustainability. However, the magnitude by which cover crops impacts SOC depends on multiple factors, including soil type, climate, crop rotation, tillage type, cover crop growth, and years under management. To elucidate how these multiple factors influence the relative impact of cover crops on SOC, we conducted a meta-analysis on the impacts of cover crops within rotations that included corn (*Zea mays* L.) on SOC accumulation. Information on climatic conditions, soil characteristics, management, and cover crop performance was extracted, resulting in 198 paired comparisons from 61 peer-reviewed studies. Over the course of each study, cover crops on average increased SOC by 7.3% (95% CI, 4.9%–9.6%). Furthermore, the impact of cover crop–induced increases in percent change SOC was evaluated across soil textures, cover crop types, crop rotations, biomass amounts, cover crop durations, tillage practices, and climatic zones. Our results suggest that current cover crop–based corn production systems are sequestering 5.5 million Mg of SOC-C per year in the United States and have the potential to sequester 175 million Mg SOC per year globally. These findings can be used to improve carbon footprint calculations and develop science-based policy recommendations. Taken altogether, cover cropping is a promising strategy to sequester atmospheric C and hence make corn production systems more resilient to changing climates

Objective 3: Distribute information to farmers

2023 Soy100 2023 meeting. The planning committee consists of Adam Kask, Maria Kessler, Maggie VanderLaan, David Iverson, Kyle Gustafson, Anthony Bly, Connie Strunk, David Clay, and Shaina Westhoff.

This year we had a successful meeting and 139 people attended the meeting. The survey showed that the presentations were well received.

New projects for 2023

New projects for 2023. Currently we have over 30 projects scheduled for 2023

Name	Treatment	Crop	County
Alverson, Keith	Soybeans	Higher population	Lake
Alverson, Keith	Corn	Lower population	Lake
Biskeborn, Scott	Xylem Plus	Corn	Brule
Biskeborn, Scott	Xylem Plus	Soybeans	Brule
Carlson, Scott	Biological or biostimulant	Corn	Kingsbury
Carlson, Scott	Biological or biostimulant	Soybeans	Kingsbury
Converse, Craig	BioniQ	Corn	Kingsbury
Converse, Craig	NanoCS	Corn	Kingsbury
Converse, Craig	Corn Root Exudate Mix	Corn	Kingsbury
Converse, Craig	Soy Root Exudate Mix	Soybeans	Kingsbury
Converse, Craig	BioCore	Corn	Kingsbury
Converse, Craig	BioCore	Soybeans	Kingsbury
Ebsen, John	Biological or biostimulant	Corn	Minnehaha
Eliason, Carl	Biological or biostimulant	Corn	Minnehaha
Fechner, Darren	Biological or biostimulant	Corn	Douglas
Fechner, Darren	Biological or biostimulant	Soybeans	Douglas
Hamilton, Mark	Homemade biological	Corn	Beadle
Hanten, Todd	Biological or biostimulant	Soybeans	Codington
Jorgensen, Bryan	Biological or biostimulant	Corn	Tripp
Jorgensen, Bryan	Biological or biostimulant	Soybeans	Tripp
McNeil, B.J.	Homemade biological	Corn	Hand
Loewe, Matt	Higher population	Soybeans	Lincoln
Loewe, Matt	Lower population	Soybeans	Lincoln
Meyer, Trace	Biological or biostimulant	Corn	Tripp
Miner, Lance	Biological or biostimulant	Corn	Brookings
Miner, Lance	Biological or biostimulant	Soybeans	Broonings
Nelson, Jon	Holganix	Corn	Kingsbury
Nelson, Jon	Holganix	Corn	Kingsbury
Nedved, Frank	Biological or biostimulant	Corn	Yankton
Nedved, Frank	Biological or biostimulant	Soybeans	Yankton
Renaas, Doyle	Biological or biostimulant	Soybeans	Lake
Scott, Kevin	Biological or biostimulant	Soybeans	Minnehaha
Strom, Corey	Biological or biostimulant	Corn	Brule
Strom, Corey	Biological or biostimulant	Soybeans	Brule
Strom, Nick	Proven40 ST	Corn	Brown

Research papers Accepted

1. Joshi, D., H. Sieverding, H. Xu, H. Kwon, M. Wang, S. A. Clay, J. Johnson, S. Westhoff, and D. Clay. 2023. A global meta-analysis of cover crop response on soil carbon storage within a corn production system. Agronomy Journal (in press).

In preparation

1. Bhattarai, D and D.E. Clay. (2024). Are the state N recommendations model appropriate for long-term no-tillage Maize in South Dakota.
2. Bhattarai, D and D.E. Clay. (2024) Soil health measurements impact on maize yield in no-tillage systems.
3. Gardezi, M., et al. Rethinking 'responsibility' in precision agriculture innovation: Lessons from an interdisciplinary research team. Big Data and Society. (Submitted).
4. Moriles-Miller, J, S.A. Clay, and D.E C;lay (2024) Influence of rye cover crop termination on early corn growth and yield in a no-tillage system
5. Methane storage potential of cropland can be reduced by time of year and fertilization

Invited presentations

1. Clay, D.E. 2023. Soil Carbon Markets, Nebraska Ethanol Board, Ethanol Forum, LaVista Nebraska, March 6-7, attendance, 150.
2. Clay, D.E. 2023. Soil Carbon Markets, SD Chapter ASFMRA annual and educational meeting, Pierre, SD March 10, 2023, attendance, 50.
3. Clay, D.E. 2022, Carbon neutrality, Kick off for endowed chair lectures at SDSU, September30, 2022. Brookings, SD attendance 30
4. Clay, D.E. 2022. Kick off meeting for RCPP, Madison SD, September 13, 2022. Attendance 120.
5. Clay, D.E. 2022. Everything counts, farm-to-biofuel carbon market opportunities. American coalition of Ethanol. Omaha, NE, August 23, 2022.

Volunteered paper

1. Miller, J, S.A. Clay, D.E. Clay, G. Reicks, D.P. Horvath, and A.L. Daaigh. Corn-rye interactions by rye termination using RNA-Seq and analysis. ASA 2022 annual meeting, Baltimore, November 7-11.
2. Kommineni, V., S. Xu., D.E. Clay, M.G. Nisrani. 2022, Soil health response to biochar and organic manure amendments in South Dakota Cover crop system. ASA 2022 annual meeting, Baltimore, November 7-11.
3. Joshi, D.R., R. Ghimire, U. Mishra, S.A. Clay, and D.E. Clay. 2022, Conservation agriculture for food security and climate resilience. ASA 2022 annual meeting, Baltimore,
4. Bhattarai, D., S.A. Clay, J. Clark, G. Hatfield, and D.E Clay. Predication of no-tillage corn N requirement using a machine learning algorithm, ASA 2022 annual meeting, Baltimore, November 7-11.

Student awards

1. Bhattarai, D. (2022) First place, oral presentation, Prediction of no-till corn N requirement using machine learning algorithm, Precision Agriculture Systems, ASA, CSSA, and SSSA international annual meeting, 6-9 November 2022, Baltimore, MD.
2. Bhattarai, D. (2022) First place, NUE Workshop Granular Hackathon Competition, Nitrogen Use Efficiency Workshop organized by The University of Nebraska-Lincoln, August 1-3, 2022. Bhattarai was the team leader of the "Jack's Hack" team.

3. Bhattarai, D. (2022) Awardee, Gerald O. Mott Meritorious Graduate Student Award, Crop Science Society of America, 2022.
4. Joshi, D.R, (2022).First place, Deep-learning and high-resolution satellite imagery to predict soybean yield. Airborne and Satellite Remote Sensing Student Oral Presentation Competition ASA, CSSA, and SSSA international annual meeting, 6-9 November 2022, Baltimore, MD.
5. Joshi, D.R. (2022) U.S. Carbon Program Leadership Award by U.S. Carbon Cycle Science Program, Washington, D.C., U.S.

Additional funding

1. Clay, D.E., Clay. S.A., Joshi, D., Westhoff, S., Reese, C.L., Reicks, G., Wang, T., and Nleya, T., Overcoming climate smart adoption barriers by demonstrating the value of linking no-tillage, cover crops, and enhanced N management into a single system, Classic USDA-NRCS-CIG program. Funding, 1,288,032. 2023-2026.
2. Bloom, P., (2022) GEVO from corn to jet fuel, 30 million dollars. SDSU 1.9 million, SDSU lead D.E. Clay. 2023-2027,

Objective 4. Students enrolled in advanced classes are using on-farm studies in undergraduate research projects.

Addition information will be made available as these studies are completed.