North Dakota State University

SOYBEAN SYMPOSIUM

BOOK OF ABSTRACTS

MARCH 20TH
2025

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SOYBEAN SYMPOSIUM

Learn about the latest in soybean research from NDSU experts

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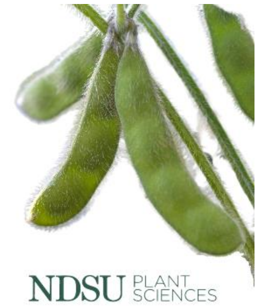

NDSU PLANT SCIENCES

Contents

Student Abstracts

Oral Presentations

1. Aditya Goyal

The global accumulation of non-degradable plastic packaging, exceeding 300 million tons annually, demands sustainable alternatives. This research explores the development of biodegradable packaging materials using soy fibers, an underutilized soybean byproduct, reinforced with biodegradable polymers. The study seeks to mitigate the environmental impact of single-use plastics while enhancing the economic potential of soybean agriculture. Soy fibers will be extracted, processed, and integrated with biodegradable polymers through graft copolymerization, employing maleic anhydride to enhance interfacial adhesion. Natural plasticizers (e.g., glycerol) and pro-oxidant additives (e.g., cellulase enzymes) will be incorporated to improve flexibility and regulate degradation, aiming for complete decomposition within 6–12 months under composting and soil conditions. The research objectives encompass the fabrication of rigid containers, flexible films, and laminates, followed by extensive evaluation of mechanical properties (tensile, flexural, impact, and tear resistance), barrier characteristics (moisture and air permeability), and biodegradability (respirometric and soil burial analyses). Initial cost estimates suggest production at \$5.20–\$7.05/kg, with a market value of \$8–\$12/kg, outperforming conventional plastics (\$2–\$4/kg). By transforming agricultural waste into high-performance, eco-friendly packaging, this study advances sustainable materials science and promotes a circular bioeconomy. The outcomes offer dual benefits: reducing environmental pollution and creating a value-added revenue stream for soybean farmers. This research underscores the potential of soy fiber-based materials to meet the rising demand for biodegradable packaging solutions, contributing to both ecological and agricultural innovation.

2. Dayne Tallier

Lindsay Malone, Christopher Augustine, Laura Aldrich-Wolfe, Brady Goettl, Leo Bortolon, Szilvia Yuja
School of Natural Resource Sciences, North Dakota State University, Fargo, ND 58102

Title: Updating Soybean Phosphorus Recommendations across ND

There is a need for a reevaluation of phosphorus (P) recommendations in North Dakota. In general, soil test P values are lower in ND than other states, necessitating more careful P-management and potentially more frequent applications. Recent research showed increases in soybean yield with P-application in Minnesota on soils with moderate P-levels, but not in North Dakota. Therefore, current ND recommendations only recommend P-applications to soybean to fields with low or very low P-levels. This project sought to reassess these recommendations with a coordinated statewide P-rate study in soybean. In addition, fertilizer P-rates recommended at low soil test P may be greater or less than what is profitable. There were 8 sites total across the state in 2023, with a repeated study in 2024. Each site had five P-rates applied and soybean yield and soil test P was measured at all sites. Of the 16 site-years, 3 sites in responded positively to fertilizer application ($p < 0.05$). Experimental units with higher than 80% relative yield also showed higher fall P test levels compared to units with less than 70% relative yield. We also looked at arbuscular mycorrhizal fungi (AMF) at 5 of the 16 sites and found that fertilizer applications did not have any impact on both colonization or soil populations. Preliminary data will be presented for both 2023 and 2024.

3. Francisca Kyei

Iris Feng, and Ademola Ajayi-Banji
North Dakota State University

Title: Anaerobic Digestion of Defatted Soybean Meal for Biogas and Biofertilizer Productions.

Anaerobic digestion is a promising biochemical waste management strategy and alternative energy source but has limiting factors like microbial adaptation to substrate and changing temperatures. The study investigates the yield of biogas produced from defatted soybean meal (DSM) and analyzes the biofertilizer potential of the digestate slurry from the biogas production process. It also explores the effect of temperature, particle size of feedstock, pretreatment and co-digestion on biogas production. This investigation intends to quantify the methane produced at 2 feedstock to inoculum ratio, pre-treatments and co-digesters to study the effect on methane production. In this experiment, the lab-scale anaerobic digester is employed while DSM is used as the sole substrate by analyzing the impact of 3 particle sizes and 2 temperature conditions. To achieve this, 6 treatments and 2 controls were studied under thermophilic (55ºC) and mesophilic (35ºC) bioreactors and the best performing temperature condition was tested with pre-treatment and co-digestion. Analysis of data collected indicates significant biogas yield across the particle sizes; 197 mL/g VS for fine, 186 mL/g VS for medium and 149 mL/g VS for large in the mesophilic and 74 mL/g VS for fine, 111 mL/g VS for medium and 51.3 mL/g VS in the thermophilic. This indicates that although biogas yield is lower at the thermophilic temperature than methane. Further tests are done to quantify the methane concentration at pre-treatment and co-digestion and to test the nutrient content of the slurry. DSM shows good biogas yielding potential which if soybean producers in North Dakota explore, would greatly decrease waste production, and provide an energy source for farmers.

4. Sarita Poudel

Renfroe-Becton, H., Mathew, F. and Webster, R.W.
Department of Plant Pathology, North Dakota State University, Fargo, ND 58102

Title: Validation of Sclerotinia sclerotiorum Apothecial Risk Models in the Northern Great Plains

Sclerotinia sclerotiorum, the causal agent of Sclerotinia stem rot (SSR), is a devastating fungal pathogen that led to the loss of over 11 million bushels in northern US soybeans in 2022. Although various management strategies are currently employed, fungicide application remains the predominant method for the control of SSR. It is very important to make these applications during the flowering period when apothecia are present on the soil surface. Improper fungicide application timing can lead to ineffective disease control. The accurate prediction of apothecial risk can provide precise timing for fungicide application. In 2018, the University of Wisconsin-Madison developed six logistic regression models for irrigated and non-irrigated fields to detect the probability of S. sclerotiorum apothecial development. There is a need to further validate the models in multiple locations for effective management. This research aims to validate these models and determine the appropriate action threshold for the Northern Great Plains. The models were validated through apothecial scouting and disease monitoring in commercial fields across North Dakota, most of which were non-irrigated. To enhance predictive accuracy, probabilities from each of the non-irrigated logistic regression models were averaged to develop an "ensemble" model. The performance of individual models and the ensemble model were evaluated. Our results revealed that the ensemble model achieved the highest accuracy, with 78%, in predicting end-of-season disease incidence (DI, %) across all fields with a 10% DI threshold and a 35% risk probability action threshold. In 2025, we will conduct multi-location validations to further refine the models. These results will be used to improve the accuracy of disease risk predictions, reducing unnecessary chemical applications for ND soybean growers.

5. Siddant Ranabhat

Guiping Yan
Department of Plant Pathology, North Dakota State University, Fargo, ND 58102

Title: Development of a real-time PCR assay for direct detection and quantification of the new root-lesion nematode species, *Pratylenchus dakotaensis* from soybean roots

Root-lesion nematodes (Pratylenchus spp.) pose a significant threat to soybean productivity. Pratylenchus dakotaensis, a newly named root-lesion nematode species from North Dakota, was found to exhibit high infection and reproduction in soybeans. Early and rapid detection of P. dakotaensis is critical for effective management, but traditional methods for nematode species identification and quantification are labor-intensive and time-consuming. Thus, the objective of this research was to develop a SYBR Green-based real-time PCR assay for rapid detection and quantification of P. dakotaensis in DNA extracts of soybean roots. The assay utilized specific primers (IC-ITS1F/IC-ITS1R), previously designed in our lab for detecting this species in DNA extracted from nematode individuals. The primer pair was specific as it detected only P. dakotaensis DNA from co-extracted root extracts and other control species. PCR inhibitors were identified in root extracts and subsequently neutralized. Sensitivity testing revealed that the assay could detect as low as 1/128th of a single nematode per 0.2 g of roots. A standard curve with high amplification efficiency (E = 98.1%) and coefficient of determination (R2 = 0.97) was generated. The assay was validated using artificially-inoculated soybean roots and infected root samples in the greenhouse. Real-time PCR estimates from both sets of samples correlated well with ¬ P. dakotaensis densities, with R2 ranging from 0.80 to 0.84. Overall, the assay provides a rapid and efficient molecular tool for detecting P. dakotaensis directly from infected soybean roots, thereby facilitating timely management of this new nematode pest.

Poster Presentations

6. Ademola Ajayi-Banji

North Dakota State is projected to produce 390 Kton surplus defatted soybean meal (DSM) by 2030. This additional meal is envisaged to be judiciously harnessed with new use; however, the environment implication of the utilization strategies is imperative in decision making. Thus, in this study, three DSM management scenarios which include anaerobic digestion of the excess defatted soybean meal with and without the application of its digestate as biofertilizer, and livestock consumption of the meal in nearby States were modeled and evaluated with life cycle assessment approach. Our results show that transportation of DSM to nearby states (Scenario 3) pose substantive environmental threat relative to other management options. For instance, the global warming and fossil fuel scarcity impacts from Scenario 3 were the highest (0.061 kg CO2 eq, and 0.017 Kg oil eq respectively); these emissions were at least 3 times the use of DSM gestates without further use of the digestate or effluent (Scenario 1). Interestingly, the carbon credit from Scenario 2, makes combining DSM digestion and the use as biofertilizer the most environmentally suitable management option. The outcome of this study is expected to provide insightful guidance on defatted soybeans management in North Dakota based on the environmental and energy performance.

7. Bohdan Domnich

Andriy Voronov
Department of Coatings and Polymeric Materials, North Dakota State University, Fargo, ND, 58108

Title: Polymer Composites from Soy Meal and Soy Hulls Modified with Soy-Based Polymers

Natural resources, such as wood components (cellulose, hemicellulose, lignin) and plant oils, draw significant interest in developing biobased polymers. Despite the advantages of soybean hulls (SH) and soybean meal (SM), such as their high abundance, low cost, and high functionality, they demonstrate low mechanical performance and lack of film-forming properties. At the same time, SH and SM's high hydrophilicity makes them incompatible with conventional polymers. In this study, we used the reaction of SH or SM with maleic anhydride via free hydroxyl groups to introduce the reactive sites for free-radical polymerization. Then, bulk free-radical polymerization of maleinized SH and SM with high oleic soybean oil-based monomer (HOSBM) was conducted. In such fashion, a simultaneous "grafting from" reaction on the fillers' surface and formation of the polyHOSBM matrix occurs. Because both components contain polyHOSBM chains, it allows homogeneous distribution of filler material and prevention of phase separation. Pristine polyHOSBM forms highly flexible, low Tg, and hydrophobic films containing functional groups for post-polymerization cross-linking via autoxidation. We observed a significant increase in the Storage modulus, incorporating up to 25 wt.% of filler material, while with further increase to 35 wt.%, the obtained composites become highly flexible and demonstrate the behavior of cross-linked elastomer. The synergistic effect of simultaneous SH and SM modification compared to sole use SH or SM was also addressed. Current work shows excellent prospects for using abundant natural materials to develop fully bio-based, high-added value products as an alternative to petroleum-based plastics.

8. Brenda Benedict Maembe

Lindsay Chamberlain Malone, Thomas Desutter, and Dean Steele
School of Natural Resource Sciences, North Dakota State University, Fargo, ND 58102

Title: Residue Management For The Future: Planting Technology to De-Risk No -Till Soybean Production

Effective residue management is fundamental for successful no-till soybean production, particularly in regions like the Red River Valley (RRV), corn residue is slow to decompose. Traditional tillage methods expose soil to erosion and crusting, but excess corn residue, might make planting difficult, resulting in poor seed-soil contact and irregular emergence. This challenge demands innovative solutions that will simplify the transition to no-till soybean production while maintaining effective residue management. This study investigated on the effectiveness of a new planter modification system developed by a startup company, Susterre, that uses high-pressure water jets to cut through residue and compacted soil, resulting in optimal seed-soil contact and consistent planting depth. Initial results from the first year of the trial (2024) revealed a significant interaction between residue treatments and planter type on soybean yield. The Planter type significantly affected soybean emergence rates, while residue treatment did not, likely because the traditional no-till planter was used one day earlier than the Susterre high-pressure water-jet planter. Additional analyses, including greenhouse gas emissions, soil nitrate levels, soil moisture, and temperature, are ongoing to further assess the implications of this planter technology. Water-jet planter technology has the potential to transform residue management practices in the Red River Valley by enhancing planting outcomes and soil health, ultimately improving productivity and sustainability in soybean farming.

9. Clara Mvuta

Soybean production in North Dakota has expanded significantly, making it one of the most cultivated crops in the state. However, the state's average yields are among the lowest in the Midwest, and the reasons remain unclear. Maturity is a critical agronomic trait influencing yield potential, especially in North Dakota's short growing season, which is limited by frost risk. To address this, early-maturing cultivars predominantly from maturity groups (MG) 00 and 0 are grown in the region. Fine-tuning soybean maturity to match local environments could help maximize yield potential. The major genetic mechanisms controlling soybean maturity are well understood, with the E1, E2, and E3 genes playing a significant role. Functional alleles of these genes result in later maturity, while null or semi-functional alleles condition earlier maturity, creating the MG 00 and 0 phenotypes. Surprisingly, functional alleles of the E3 gene have been detected in some lines from the North Dakota State University (NDSU) soybean breeding program, challenging current understanding and highlighting the need for deeper investigation into genetic factors influencing maturity. This research aims to identify the maturity alleles present in the NDSU soybean breeding program. A GWAS will be conducted on MG 00 and 0 lines from the soybean germplasm collection to identify minor-effect maturity genes. If new genes are found, the NDSU germplasm collection will be screened for these genes. Additionally, heritability and stability analysis will be done, to assess how heritable maturity trait is at NDSU germplasm. This study could enhance understanding of the genetic mechanisms underlying soybean maturity in North Dakota, and potentially identify novel genetic factors contributing to yield gains.

10. Dinesh Poudel

Guiping Yan, Febina Mathew and Richard W. Webster
Department of Plant Pathology, North Dakota State University, Fargo, ND 58102

Title: Evaluation of soybean accessions for dual resistance to the soybean cyst nematode Heterodera glycines and the fungus Clonostachys rosea

Soybean cyst nematode (SCN; Heterodera glycines) is the most devastating disease of soybean. The ascomycete fungus, Clonostachys rosea, can cause taproot and lateral root necrosis in soybean. Identifying soybean accessions with dual resistance is crucial to provide breeding programs with valuable sources of resistance. In this study, 29 soybean accessions from Soybean Germplasm Collection Center were first screened for resistance to two SCN populations, HG type 2.5.7 and 0 under controlled greenhouse conditions. Twenty-two accessions showing varying levels of resistance to SCN were further evaluated for resistance to C. rosea. Soybean accessions were inoculated with C. rosea-infected sorghum seeds and assessed for root rot symptoms in three greenhouse experiments. Significant differences in root lesion length and root rot severity were observed among these accessions. Five accessions (PI548642, PI603153, PI603169, PI603426B, and PI603438A) showed no significant difference in root rot severity when compared to the control 'Barnes' inoculated with non-infected sorghum seeds, suggesting potential resistance to C. rosea. In contrast, PI597391C and PI603148, which exhibited higher disease severity to C. rosea, showed a significant reduction in root fresh weight, and a significant increase in root lesion length and root rot severity at 30 days post-inoculation. PI548642 was found to be resistant to both SCN and C. rosea. The variation in resistance among soybean accessions against the two pathogens and the impact on growth parameters underscore the need to identify and integrate resistant lines into breeding programs to develop cultivars with enhanced resistance to C. rosea and SCN.

11. Gilda Mejia Tebelan

Cole Williams, Barney Geedes, Kelsey Griesheim, Felix Fritschi and Carrie Miranda
Department of Plant Sciences, North Dakota State University, Fargo, ND 58102

Title: Increasing Yield under Drought through Sustained Symbiotic Nitrogen Fixation in North Dakota

Low water conditions are a major yield limiting factor in western North Dakota, with the average yield between 15-20 bushels per acre. While there are several traits that can help mitigate the negative yield effects of low water, many come with an initial yield potential loss. One low water conditions, mitigation trait that does not compromise yield potential is sustained symbiotic nitrogen fixation (SNF). With low soil water content, soybean symbiotic N2 fixation rates decline in advance of other physiological processes. A greater ability to sustain SNF under low water conditions results in higher yields in low water conditions without sacrificing yield potential in well-watered conditions. The ability to sustain SNF in soybeans has been shown to have a genetic basis, and the trait has been observed in the U.S. germplasm collection. The University of Arkansas successfully created two elite lines containing the SNF trait. Our goal is to incorporate SNF into NDSU germplasm using the Arkansas cultivars R01-416F and R01-581F. If the trait proves to be useful in the western North Dakota environment, it could have significant economic impact for the state.

12.Jaime Chambers

Grady J. Gullickson, Madeliene S. Nichols, Yssi L. Entzie, Jessica G. Syring, Joshua V. Wianecki, Lydia E. Trandem, Garrett Havelka, Kendall C. Swanson, Miranda A. Meehan, and Zachary E. Carlson
Animal Science Department, North Dakota State University, Fargo, ND 58102

Title: Effects of protein supplementation to backgrounding cattle in a winter bale grazing system on growth performance, forage production and soil health

To evaluate how supplemental protein source (PS; dried distiller's grains plus solubles (DDGS) or soybean meal (SBM)) and frequency (SF; daily (D) or three times weekly (3x)) in a winter bale-grazing system on growth performance, forage production and soil health. Seventy-two calves (BW = 249 ± 27 kg) grazed 44-d. Calves were stratified by BW and assigned to treatments. Paddocks contained 10 grass-hay bales (495 ± 32.6 kg) and were 0.18 ha. Calves were supplemented on a dry matter basis, D received 0.75% of BW and 3x received 1.75% of BW. There were no PS × SF interactions ($P \geq 0.49$) for EBW, ADG, DMI or biomass. There were no differences ($P \geq 0.32$) due to SF for EBW, ADG or DMI. There were no differences ($P = 0.21$) due to PS for EBW and ADG. DMI tended ($P = 0.09$) to be greater for cattle supplemented with SBM. PUN was influenced ($P < 0.05$) by PS, SF, day, and all interactions, and increased with CP. Forage biomass was influenced ($P = 0.0002$) by distance from bale center but not treatment. Paddocks supplemented 3x had lower ($P < 0.05$) TC. Total N (0-0.15m) tended ($P = 0.053$) to increase in SBM fed paddocks. K was greater ($P = 0.008$) toward the bale center. Results suggest SBM supplementation improved soil health and producers can utilize a winter bale grazing system with backgrounding cattle while supplementing either DDGS or SBM as few as 3x with minimal influences on animal performance.

13.Jithin Mathew

Ramita Shah, Anup Das, Carrie Miranda, Gustavo Kreutz, and Paulo Flores
Department of Agricultural and Biosystems Engineering, North Dakota State University, Fargo, ND 58102

Title: Developing a Multi-Sensor Rover Platform for Soybean Pod Counting and Yield Prediction

Image-based phenotyping plays a crucial role in optimizing crop yield prediction, ultimately contributing to the development of superior soybean varieties with enhanced yield productivity. In a high-throughput agronomic yield trial, accurately predicting soybean yield based on strong phenotypic correlations is essential for selecting optimal cultivars for subsequent breeding stages. The existing method for non-destructive yield estimation in soybeans are performed manually and are error prone. Despite the potential of imaging technologies, real-time soybean yield prediction remains underexplored, with limited research on fully integrated computational pipelines capable of automating this process efficiently. This project aims to develop a robust, high-throughput phenotyping platform to assist breeders in making data-driven selections for improving yield traits in soybeans. To achieve this, we designed an advanced sensor network integrating multiple RGB-D (Red, Green, Blue, and Depth) sensors, managed by a centralized host, to facilitate real-time data acquisition, pod detection, and count, subsequently aiding in yield estimation. The system employs dual depth sensors positioned opposite to each other to enhance pod counting accuracy from synchronized RGB and depth data streams. This study expands upon our previous methodology, which utilized a single depth sensor and a timer-based image acquisition for pod counting in soybeans yield trials. By incorporating multiple sensors and transitioning to video-based data acquisition setup, coupled with object-tracking algorithms within the YOLO architecture, we aim to significantly enhance the precision, efficiency, and scalability of the platform. Towards this goal, a rower platform was developed to integrate sensors, network hardware, computing units, and electronic components for both controlled and field-based applications.

14. Katrina Kratzke[1,2]

Joshua Wianecki[1,2], Miranda Meehan[1], Kevin Sedivec[2,3], Lindsay Chamberlain Malone[2], Zachary Carlson[1]
[1]Department of Animal Sciences, North Dakota State University, Fargo, ND. [2]School of Natural Resource Sciences, North Dakota State University, Fargo, ND. [3]Central Grasslands Research Extension Center, North Dakota State University, Streeter, ND.

Title: Short Term Impacts of Grazing Cover Crops on Profitability and Soil Health.

Cover crops (CC) as part of an integrated crop livestock system (ICLS) may extend the grazing season and off-set the costs of CC establishment. The objective of this study was to determine the effects of grazing CC on soil health and profitability. Nine 1.78 ha plots were assigned one of three treatments: dual (fall and spring) grazing (DG), spring grazing (SG), and control, which was divided into no graze (NG) and no winter rye (NR). Winter rye was planted following cash crops in the fall (2022-2024). In fall 2022, spring 2023 and 2024 CC were grazed for 0.6 animal unit months (AUMs), 3.36 AUMs, and 0.98 AUMs, respectively. Fall 2023 and 2024, DG plots were not grazed due to low forage production. Winter rye was evaluated pre- and post-grazing for biomass production. Fall grazing did not impact spring CC production. Grazing did not alter soil chemical properties or negatively impacted soil physical properties. Cover crops significantly reduced weed cover. Weed suppression was unaffected by grazing. Cash crops were evaluated by staging, stand counts, and yield. There were no differences in crop performance between treatments. Production economics were estimated by partial budgeting that accounted for cost of CC establishment and savings in feed and yardage. The cost of establishing a CC was approximately \$17.4/ha/yr. Grazing either resulted in a net income or provided a return on CC investment across all years. Grazing CC can extend the grazing season reducing feeding costs without negatively impacting soil health or crop performance.

15. Kudirat Alarape

Dr Ademola Hammed and Dr Clementson Clairmont
Environmental and conservation science, North Dakota State University, Fargo, ND 58102

Title: Development of biochar-biocatalyst for soymeal protein hydrolysis

Immobilizing enzymes on a porous material such as biochar due to its large surface area and high porosity, may increase access to substrates thereby enhancing enzyme activity. Alcalase, a serine endopeptidase catalyzes the breakdown of proteins into peptides and amino acids. However, it is highly sensitive to environmental conditions such as pH, temperature and is also very costly. Immobilizing alcalase on porous support can improve its stability, facilitate easy recovery and improve reusability. This research aims to investigate and establish an effective protocol for alcalase enzyme immobilization on biochar for soymeal protein hydrolysis. The effect of biochar surface activation and modification was examined to determine the binding capacity of the enzyme alcalase onto the support. FTIR and SEM were employed to analyze the structure and morphology of the porous support before and after immobilization. The efficiency of immobilization and hydrolytic performance of free and immobilized enzymes will be evaluated through protein digestibility assays. The stability and reusability of the biochar-biocatalyst support will also investigated. Glutaraldehyde functionalized biochar (FABPA) shows the highest immobilization capacity overall (64.22mg/g) at the low concentration of 10mg/ml with a peak at 30mg/ml (77mg/g) followed by phosphoric activated biochar (ABPA) peaking at 50mg/ml (70.81mg/g). The optimum enzyme concentration for immobilization is 30mg/ml. FTIR and SEM show a difference in structure and morphology of the supports due to the insertion of functional groups. It is expected that functionalized biochar will enhance Alcalase catalytic efficiency, making it a suitable biocatalyst for soymeal protein hydrolysis.

16.Madeeha Matloob

Renfroe-Becton, H., Mathew, F., and Webster, R.W.
Department of Plant Pathology, North Dakota State University, Fargo, ND 58102

Title: Evaluation of Commercial Biocontrol Products Performance for Managing Soilborne Pathogens in North Dakota Soybean Fields.

Root rot diseases caused by soilborne pathogens significantly threaten soybean production, requiring effective and sustainable management strategies. This study evaluated the efficacy of seven commercial biocontrol products against infection by Rhizoctonia solani in inoculated soybean fields across two North Dakota locations, Oakes and Fargo, in 2023. Using a randomized complete block design, we assessed commercial biocontrol products Avodigen (Bacillus licheniformis strain FMCH001, Bacillus subtilis strain FMCH002, 1.02 fl oz/cwt), F4034-5 (Bacillus subtilis strain RTI477, Bacillus velezensis strain RTI301, 0.64 fl oz/cwt), RootShield Plus Granule (Trichoderma harzianum Rifai strain T-22, Trichoderma virens Strain G-41, 24 lb/cwt), RootShield Plus seed treatment (Trichoderma harzianum Rifai Strain T-22, Trichoderma virens strain G-41, 4 lb/cwt), Howler (Pseudomonas chlororaphis strain AFS009, 5 lb/cwt), and Heads Up (extract of Chenopodium quinoa saponins, 8 fl oz/cwt), comparing them to a non-treated control and the fungicide Cruiser Maxx APX (metalaxyl, sedaxane, thiabendazole, fludioxonil, 3.9 fl oz/cwt) was included as a positive control. Individual plots were 20' x 10'at both locations with four repetitions (plots) per treatment. Data recorded from these trials included stand count, root rot severity, yield, soybean oil, and protein content. The data suggested potential effects on stand count, root rot severity, yield, oil content, and protein content, though these effects were not significant ($P>0.05$). Cruiser Maxx APX exhibited the highest stand count (210 plants/plot) and lowest root rot severity (22.35%), followed by RootShield Plus Granule (201 plants/plot, 23.76%) and Heads Up (203 plants/plot, 29.83%). The non-treated control showed the lowest stand count (170 plants/plot) and highest root rot severity (32.12%).

17.Marcel Roy Domalanta

Fluoropolymers are gaining interest from the coating industry thanks to their mechanical integrity, thermal stability, hydrophobicity, and chemical inertness. However, their nonstick nature limits their applications as it often leads to poor film adhesion to various surfaces. While various approaches have been explored to improve fluoropolymer adhesion, their practical application remains restricted due to their complexity, cost, and environmental impact. In recent years, extracts from fruits, leaves, and plants have been used as eco-friendly additives for polymer coatings due to their ready availability, sustainability, low toxicity, and compatibility. Herein, soybean extracts (SEs) were employed as a green additive to enhance both the surface adhesion and corrosion protection of poly(vinylidene fluoride-co-hexafluoropropylene) (PVDF-HFP) coatings on carbon steel. Results showed that the inclusion of SEs increased the affinity between the fluoropolymer coating and metal surface. This improvement is attributable to the presence of abundant heteroatoms and pi-electrons from isoflavones in SEs and their capability to facilitate interactions at the coating-metal interface. Moreover, the coatings were able to suppress corrosion in 3.5 wt% NaCl solution, peaking an impedance modulus of ∼108 Ω cm2 after 7 d of continuous immersion, even at low SE doses. This result was supported by microscopic, spectroscopic, wettability, surface mechanical, thermal stability, cyclic corrosion, and simulation studies. Overall, our strategic approach highlights the beneficial use of SE additives toward formulating cost-effective, sustainable, and high-performance fluoropolymer coatings for a wide range of surface protection applications.

18.Rachel Konshok

Sclerotinia stem rot (SSR), caused by Sclerotinia sclerotiorum, is a major threat to soybean production in North Dakota with limited genetic resistance available due to its quantitative nature. Effective management requires an integrated approach, such as combining fungicide applications with host resistance. Our objective was to identify the treatment or combination of treatments that resulted in the least amount of SSR under naturally inoculated field conditions. The treatments studied were fungicides—boscalid (Endura) at a rate of 8 oz/ac and Thiophanate methyl (Topsin) at a rate of 20 floz/ac—and soybean cultivars with differing susceptibilities to SSR. Three genotypes were selected for this trial: W19-2484 (highly resistant, MG: 1.5), 51-23 (moderately resistant, MG: 2.3), and MN 1410 (moderately susceptible, MG: 1.4). The plants were grown under irrigated field conditions with three repetitions per treatment and fungicide applications were made at the R2 growth stage. Disease incidence (%) and severity were assessed at the R6 stage, and yield (bu/acre), protein and oil content (%), and sclerotial mass were recorded at harvest. Partial profitability was later recorded. Results from the first year indicated that Endura outperformed Topsin in reducing disease severity index ($p = 0.065$) and yield ($p = 0.087$). Additionally, MN 1410 showed significantly greater yield ($p < 0.001$) and partial profitability ($p < 0.001$) compared to the other two genotypes. However, these results are from a single season with low disease pressure, so greater replications are needed.

19.Rachel Yeum

Febina Mathew, Richard Wade Webster, and Suzette Arcibal Baldwin
Department of Plant Pathology, North Dakota State University

Title: The NDSU Plant Diagnostic Lab: A Key Resource for Soybean Disease Diagnosis and Management

The Plant Diagnostic Lab (PDL) provides high-quality, research-based diagnostic services to assist farmers, agronomists, and various stakeholders in identifying and managing plant diseases. As soybean production expands in North Dakota, the incidence of soybean diseases has increased, making accurate and timely diagnosis critical for effective disease management. Over the past several years, soybeans have been the most frequently submitted field crop for diagnosis from North Dakota and Minnesota. In the past three years, PDL has diagnosed a range of soybean diseases, including soybean cyst nematode (Heterodera glycines), Fusarium rot (Fusarium spp.), Phytophthora root rot (P. sojae), charcoal rot (Macrophomina phaseolina), and brown stem rot (Cadophora gregata), as well as abiotic disorders. In 2024, through submitted samples, the presence of sudden death syndrome (Fusarium virguliforme) was confirmed in Cass, Dickey, and Richland counties, marking its spread beyond its initial detection in Richland County in 2018. Due to similar visual symptoms among root diseases, molecular diagnostics are essential for accurate identification. To enhance PDL's diagnostic capabilities, the North Dakota Soybean Council (NDSC) has supported the PDL in developing advanced molecular assays that can simultaneously detect multiple pathogens, including Fusarium, Rhizoctonia, Phytophthora, and Pythium. These multiplex assays save time and resources, providing rapid, accurate results to support informed management decisions during the growing season and long-term crop planning. By leveraging cutting-edge diagnostic technologies, the PDL plays a vital role in disease surveillance, early detection, and management strategies, helping protect soybean yields and enhance farm profitability.

20. Tawakalt Ayodele[1]

Clairmont Clementson[2] & Ademola Hammed [1,2]
[1] Environmental & Conservation Sciences, North Dakota State University, Fargo, ND 58102
[2] Agricultural and Biosystems Engineering, North Dakota State University, Fargo, ND 58102

Title: Microbial Protein Production Using a Controlled Feeding Strategy

The increasing global population has heightened the demand for sustainable protein sources, positioning microbial protein (MP) as a promising alternative. However, conventional carbon (e.g., glucose) and nitrogen sources (e.g., ammonia, urea) for MP production pose significant environmental and economic challenges. This study explores the use of switchgrass hydrolysate, produced via enzymatic hydrolysis, as a carbon source and the nitrogen fixation capability of Klebsiella oxytoca M5A1 for MP production. Protein yield was quantified using the Bradford assay, and glucose utilization and organic acid production were monitored via high-performance liquid chromatography (HPLC). A novel cultivation strategy was employed, where half of the substrate was added initially, and the remainder was introduced dropwise at a flow rate of 1 mL/h. The highest protein concentration of 843 µg/mL was observed at 32 hours, demonstrating peak production during the early cultivation phase. Comparative analysis with a control experiment confirmed that dropwise substrate addition enhanced product yield. HPLC results revealed dynamic profiles of glucose consumption and organic acid production. These findings demonstrate that utilizing switchgrass hydrolysate as a biomass-based substrate, along with the nitrogen-fixing ability of Klebsiella oxytoca M5A1, provides a sustainable and cost-effective approach for MP production. Additionally, the controlled dropwise substrate addition strategy effectively optimized yield.

21. Tetiana Shevtsova[1]

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Title: Rheological Study of Lamellar Gels based on Soybean Oil-Based Polymeric Surfactant

In this study, sustainable alternating copolymer (MHOS) was synthesized by combining maleic anhydride (MAn) with a high-oleic soybean oil-based acrylic monomer (HOSBM) in chain copolymerization. Chemical composition of the copolymer, which contains hydrophilic and hydrophobic fragments alternating in the chain was confirmed FTIR and ^{1}H NMR spectroscopy. The surface activity of MHOS was assessed by determining its critical micelle concentration (CMC) using surface tension and pyrene solubilization. The ability of MHOS to efficiently solubilize hydrophobic Nile Red molecules was demonstrated using UV-VIS spectroscopy. Furthermore, in this study, MHOS was applied in designing a cream formulation for post-operative care of piglets after castration, utilizing the wound-healing properties of oleic acid and fish oil. A range of formulations combining MHOS (as lower hydrophilic lipophilic balance (HLB) material) with sucrose palmitate and lecithin (both higher HLB counterparts) were tested to optimize properties and performance of resulted lamellar gel networks (LGNs). Rheological assessment at 20°C and 40°C reveals shear-thinning behavior, with sucrose palmitate being more beneficial in mixture with MHOS in comparison to lecithin. Differential Scanning Calorimetry (DSC) and cryo-SEM analyses confirm the thermal stability and formation of LGNs in the cream, indicating this materials potential to be applied in wound care.

22.Urmi Das[1]

Carrie Miranda[2], Eglantina Lopez Echartea[1], Barney Geddes[1]
[1]Department of Microbiological Sciences, [2]Department of Plant Sciences, North Dakota State University

Title: Potential For Combatting Iron Deficiency Chlorosis with the Soybean Microbiome

Iron deficiency chlorosis (IDC) is a prevalent issue that significantly impacts soybean growth in North Dakota. The yellowing of leaves in the affected plants stems from inadequate chlorophyll formation, primarily due to the poor functioning of iron-dependent enzymes involved in chlorophyll biosynthesis. While various management practices exist to mitigate IDC, most are neither cost-effective nor environmentally sustainable. Research indicates that plants can alter their microbial communities as an adaptive response to iron deficiency. Our study focuses on understanding the compositional changes of the soybean microbiome under iron deficiency chlorosis, with the goal of reducing IDC using plant microbiome members. We sampled four soybean genotypes with different levels of IDC tolerance across four field locations in North Dakota that showed varying degrees of iron deficiency and evaluated the microbial community composition in the soybean rhizosphere and endosphere. Our results showed a significant correlation between the structure of the soybean rhizosphere microbiome and the iron levels in the soil. We hypothesize that the compositional changes in plant microbiome could lead to more beneficial microbes that help to alleviate IDC. We optimized a high-throughput cultivation method to isolate soybean bacterial communities and successfully developed a sterile assay to screen for microbial treatments that can reduce IDC from plants. Preliminary data indicated that microbial inoculants showed significant promise in reducing IDC symptoms. Moving forward, leveraging this system to identify and characterize individual microbes with the potential to mitigate IDC could offer a powerful strategy for creating sustainable management solutions to tackle this nutrient stress.

23.Vanessa Louks

Renfroe-Becton, H., Mathew, F., Webster, R. W.
Department of Plant Pathology, North Dakota State University, Fargo, ND 58102

Title: Evaluation of Effectiveness and Economic Viability of Seed Treatments for Control of Early Season Soybean Pests

For over a decade, production of soybean has been rapidly increasing in North Dakota. Due to this expansion, there has been an influx of soybean seedling disease pressure. To better manage these diseases, we propose to investigate the efficacy of various commercial soybean seed treatments in mitigating root rot severity, protecting soybean stands, and optimizing yields. In 2024, field trials were ran at three different NDSU Research Center locations. These trials have been grouped into Eastern ($n = 2$) and Western ($n = 1$) locations. Each trial evaluated nine commercially available seed treatments, including fungicides, insecticides, and a non-treated control. Our findings indicated a statistically significant improvement ($P < 0.05$) in disease management and yield in the Eastern region when multimode-of-action seed treatments were used, compared to non-treated seeds. However, no similar benefits were observed when using single mode of action seed treatments. In the Western region, non-treated seeds produced the highest yield, and the multimode-of-action fungicide treatments resulted in lower yields than the non-treated control. In conclusion, these studies support that seed treatments provide a beneficial effect on soybean production in Eastern North Dakota, but it is not supported that this benefit extends to Western North Dakota under the conditions tested.

Non-Student Abstracts

24.Ben Harms

Forrest Hanson, Gustavo Kreutz, Anser Mahmood, Nonoy Bandillo, Matthew Hudson, Carrie Miranda
Department of Plant Sciences, North Dakota State University, Fargo, ND 58102

Title: Genetic Diversity Analysis of North Dakota Public Soybean Breeding Program Cultivars

Soybean (Glycine max) is a critical crop globally, valued for its protein and oil content. However, genetic diversity in soybean breeding programs has been constrained by historical bottlenecks, particularly in high-latitude regions such as North Dakota, where environmental conditions necessitate maturity group (MG) 00 and 0 cultivars. This study examines the genetic diversity within the North Dakota State University (NDSU) soybean breeding program using pedigree, coefficient of parentage (CP), and SNP-based analyses. Pedigree tracing of 40 NDSU cultivars revealed a genetic base derived from 49 founders. CP analysis confirmed these findings, emphasizing dependence on limited germplasm with the top ten founders accounting for over 70% of the genetic background, with Mandrin (Ottawa) alone contributing 24%. The construction of SNP-based dendrograms and genetic relationship structures delineated genetic clusters and allowed the identification of relationships among cultivars and founders. Notably, the specialty food grade natto cultivars formed a distinct cluster, while commodity cultivars exhibited genetic overlap reflective of shared parental lines. Population structure analyses highlighted five genetic subpopulations, emphasizing the reliance on specific ancestral germplasm for breeding. This study underscores the need to diversify breeding materials to prevent genetic gain plateaus in MG 00 and 0 soybeans, thereby enhancing yield potential and adaptability in high-latitude regions. By integrating new germplasm and leveraging these genomic insights, the NDSU breeding program can better optimize genetic resources, ensuring the development of superior cultivars to address regional challenges and improve North Dakota's soybean yields.

25.Bijula Sureshbabu

Denis Colombo, Milsha George, Taofeek Mukaila, Nitha Rafi, Dilorom Rasuleva, Richard Webster and Febina Mathew
Department of Plant Pathology, North Dakota State University, Fargo, ND 58102

Title: Survey of Soil Fungal Pathogens in Commercial Soybean Fields in North Dakota

Seedling diseases in soybean (Glycine max L.) can significantly affect yield, with an estimated loss of 0.09 million metric tons in the United States in 2023. In this study, we examined the prevalence of fungal pathogens in 102 commercial fields across 30 counties in 2023 and 63 fields in 16 counties in 2024 in North Dakota. Soil samples were collected in a 'W' pattern across each field, representing 0.283 hectares. The subsamples from each field were mixed and combined into a single core sample for analysis. The samples were baited using seven-day-old pregerminated seedlings of USDA G. max accessions in a rolled-paper towel assay, maintained at 60% water-holding capacity for 10 days. Six seedlings were baited per soil sample. Infected seedling tissues were then incubated on potato dextrose agar (PDA) plates for 10 days at 22±2°C. Putative fungal colonies were transferred to fresh PDA plates using the hyphal tipping method and identified based on cultural and morphological characteristics such as colony growth rate, pigmentation, septations in hyphae, and the type and shape of fruiting bodies and spores. The fungal genera identified included Alternaria, Fusarium, Penicillium, Macrophomina, Rhizoctonia, and Rhizopus from both years. Among these, Fusarium was the most prevalent (84.09% in 2023 and 91.1% in 2024), followed by Macrophomina (11% in 2023 and 4% in 2024). This study highlights the widespread occurrence of fungal pathogens in North Dakota soils, underscoring the need for effective disease management strategies to mitigate their impact on soybean production.

26.Denis Colombo

Nitha Rafi, Milsha George, Rachel Yeum, Suzette Baldwin, Richard Wade Webster, and Febina Mathew
Department of Plant Pathology, North Dakota State University, Fargo, ND 58102

Title: Identification of the Fungal Pathogen Causing Sudden Death Syndrome in North Dakota Soybean Fields

In North Dakota, Sudden Death Syndrome (SDS) in soybean (Glycine max L.) was historically of minor concern until 2024, when the disease was observed in commercial soybean fields in Cass, Dickey, and Richland counties. This study aimed to accurately identify the fungal species responsible for SDS in North Dakota through molecular analysis. A survey was conducted in 42 commercial soybean fields across eight counties in southeastern North Dakota, where plant samples exhibiting SDS symptoms (interveinal chlorosis, necrosis, leaf curling, and defoliation) were collected. Fungal isolation was performed on potato dextrose agar (PDA) using the spore suspension and root dilution methods. Culture plates were incubated at 23±2°C, resulting in the recovery of 34 Fusarium isolates. Single-spore isolations were performed to obtain pure cultures. Colonies on PDA were white to yellowish, forming bluish-gray sporodochia in the dark and producing falcate, septate macroconidia with a foot cell, smaller oval microconidia, and distinctive comma-shaped conidia. DNA was extracted, and the translation elongation factor 1-alpha (tef1) gene was sequenced to confirm species identity. Phylogenetic analyses using maximum parsimony and maximum likelihood were performed on tef1 sequences from four isolates and type cultures of Fusarium species. These isolates are grouped into a single monophyletic clade, along with the Fusarium virguliforme strain NRRL 31041. Bootstrap support was 99% in the maximum parsimony trees and 86% in the maximum likelihood tree. Future studies will focus on screening soybean varieties for disease resistance and evaluating the effectiveness of fungicide seed treatments against F. virguliforme.

27.Eugene Caldona

Department of Coatings and Polymeric Materials, North Dakota State University, Fargo, ND, 58102, USA

Title: High-performance semi-fluorinated fluoropolymer coatings modified by soybean extracts

Fluoropolymers are gaining interest from the coating industry due to their mechanical strength, thermal stability, hydrophobicity, and chemical resistance. However, their nonstick nature limits their applications as it often leads to poor film adhesion to various surfaces. In this work, we explore the efficacy of soybean extracts (SE), both in their polar and nonpolar form, in improving the surface adhesion of poly (vinylidene fluoride-co-hexafluoropropylene) (PVDF-HFP) coatings, while minimizing the effects of corrosion. The adhesion improvement by the polar SE can be attributed to the presence of abundant heteroatoms and pi-electrons from isoflavones in the extract and their capability to facilitate interactions at the coating-metal interface. Meanwhile, the enhanced adhesion brought about by the addition of nonpolar SE, in the form of epoxidized soybean oil, can be credited to its ability to crosslink with the hydroxyl-modified PVDF-HFP and form highly robust coatings. These environment-friendly and sustainable strategies are aimed at maximizing the benefits of fluoropolymer coating properties across a wide array of surface protection applications.

28.Febina Mathew

Department of Plant Pathology, North Dakota State University, Fargo, ND 58102

Title: Sudden Death Syndrome in North Dakota Soybean Fields

Sudden Death Syndrome (SDS) is a major threat to soybean (Glycine max L.) production in the United States. Although first identified in North Dakota in 2018, SDS was found to be prevalent in 2024. A total of 42 commercial fields were surveyed across eight counties, and disease incidence varied from 5% to 60%. Additionally, plant samples suspected of SDS were received from the Plant Diagnostic Lab at North Dakota State University. These plants displayed symptoms of SDS, including foliar chlorosis, necrosis, severe defoliation, brown discoloration on the lower stem, and a bluish spore mass on the taproot. The fungus was isolated by preparing a spore suspension from root tissues and culturing it on quarter-strength potato dextrose agar. The causal fungus was identified as F. virguliforme through DNA extraction and amplification of a 375 bp DNA fragment within the intergenic spacer region specific to the fungus. Several factors may have caused the spread of SDS across North Dakota. High precipitation levels throughout the early to mid-growing season resulted in wet soil conditions. Compounding this issue, the presence of high soybean cyst nematode populations in these areas can place additional stress on the plants, making them susceptible to SDS. With SDS diagnostic efforts now significantly enhanced, our focus is shifting toward developing and implementing effective disease management strategies to help ND soybean farmers protect soybean yields.

29.Milsha George

Nitha Rafi, Karthika Mohan and Febina Mathew
Department of Plant Pathology, North Dakota State University, Fargo, ND 58102

Title: Leveraging Metatranscriptomics to Investigate Early Pathogenic Responses in Soybean to Fusarium

Seedling diseases caused by Fusarium, Phytophthora, Pythium, and Rhizoctonia, result in significant yield losses to soybean production in the United States. In this study, we use a metatranscriptomics approach to detect seedling pathogens actively associated with soybean roots. Seven-day-old pre-germinated seedlings of the USDA soybean accession 'Williams 82' were baited in soil samples collected within a soybean field at the North Dakota State University Research Farm (Fargo, ND), following the W-pattern sampling method. The seedlings were baited using the roll towel method and incubated at 22 ± 2°C. Root samples were collected at 24- and 144-hours post-baiting and flash-frozen using liquid nitrogen. Total RNA was extracted, converted to cDNA, and sequencing libraries were prepared. RNA-seq reads were aligned to various custom assembly databases, including NCBI, and Gene Ontology (GO), for taxonomic and functional analysis. Taxonomic profiling of the microbial communities at 24 and 144 hours revealed the most abundant classes were Gammaproteobacteria and Sordariomycetes, with the dominant genera being Pseudomonas and Fusarium. The relative abundance of Fusarium sp. increased from 0.20% at 24 hours to 0.51% at 144 hours, while Pseudomonas sp. showed a decline from 1.15% to 0.49%. GO enrichment analysis of differentially expressed genes at 144 hours revealed an upregulation of oxidoreductase activity, which are one of the key components of the plant defense response to pathogens. This study highlights the potential of metatranscriptomics for the early detection of Fusarium and other organisms.

30.Taofeek Mukaila

Dinesh Poudel, Nitha Rafi, Prabhat Poudyal, Guiping Yan, Richard W. Webster, and Febina Mathew.
Department of Plant Pathology, North Dakota State University, Fargo, ND 58102

Title: Interaction Between Soybean Fusarium graminearum and Soybean Cyst Nematodes

Soybean (Glycine max L.) is an important crop in the United States, serving as a major source of protein and oil for humans and animals. However, soil-borne diseases such as Fusarium root rot (Fusarium spp.) and soybean cyst nematode (SCN; Heterodera glycines) pose significant threats to soybean production, with an estimated total yield loss of over 2.6 MMT in 2023. Since species of Fusarium and SCN can co-occur in the same field, unraveling the interaction between these pathogens is crucial for understanding the disease complex. This study examined the interaction between Fusarium graminearum (FG) and SCN (HG 2.5.7) using the susceptible cultivar 'Williams 82'. The experiment was conducted in a completely randomized design with four treatments (FG only, SCN only, FG + SCN, and a non-inoculated control) and five replications per treatment, using an inoculum-layer method in a growth chamber (22±2°C). After 42 days of post-inoculation, the disease severity was rated and the results were analyzed using nonparametric statistics to compare the relative treatment effects (RTEs). The FG and FG + SCN treatments exhibited significantly greater root rot severity ($P < 0.001$) compared to the control, while the SCN-only treatment showed a significantly greater egg count ($P < 0.001$). Future research could explore additional factors, such as environmental conditions and inoculation methods, that may influence the interaction between these pathogens.

31.Sunil Bhandari

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Title: Soybean can be successfully grown using reduced tillage in the Red River Valley

Soybean is one of the most widely planted crops in North Dakota, with an estimated 6.8 million acres planted, producing over 250 million bushels in 2024. In the Red River Valley (RRV), soybean is typically rotated with corn, wheat, and sugarbeet. For many years, these crops have been produced using conventional tillage practices. Since a significant portion of the corn, soybean, and wheat produced is for export, it's essential to ensure these products meet purchaser expectations. Increasingly, markets are requiring agricultural production to minimize greenhouse gas emissions, typically by reducing tillage. The objective of this research was to determine whether soybean, corn, wheat, and sugarbeet can be grown in different crop sequences under reduced tillage without adversely affecting yield, quality, or microbial and beneficial populations. Field trials were conducted at Prosper, ND, from 2021 to 2024, using three different tillage types: no-till, strip tillage, and conventional tillage. The results indicated that tillage type did not significantly affect the yield of any crop. Soybean yield consistently ranged from 42 to 45 bushels per acre under favorable conditions. Soil microbial communities were unaffected by the crops or tillage methods, though taxon-level variations were noted. Soil erosivity was lowest when the soil was covered, a result of broadcasting the seeds. Trapped insect numbers peaked in weeks 1 and 3, with corn and wheat hosting the most insects. Earthworms, indicators of soil health, were evenly distributed across crops and tillage methods. This research demonstrates that soybean, corn, sugarbeet, and wheat can be successfully grown under reduced tillage in the Red River Valley, with no significant adverse impacts on yield, quality, or soil health.

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