



BRINGING RESEARCH TO FARMERS

2023 Research Report



FUNDING SUCCESSES

Hello. My name is Jim Specht. I am a native Nebraskan - born & raised on a Panhandle NE farm. I was a UNL Professor in Soybean Genetics-Physiology-Production research for 40 years. Thereafter, for the past decade, I have served as a scientific advisor for the Nebraska Soybean Board (NSB) to provide technical advice & expertise relative to research proposals that NSB considers in March of each year, when it allocates checkoff funding to the scientific research projects that have the greatest potential for generating results that will lead to greater profitability for Nebraska's 23,000 soybean producers.



Dr. Jim Specht

The best NSB-funded production research projects are those that focus on these goals (1) increase on-farm soybean yield potential via genetic (improved varieties) and agronomic (improved management technologies), (2) protect that on-farm yield potential from being lessened by soybean pests, notably diseases (viral, bacterial, fungal), parasites (SCN), insects, and weeds, and (3) achieve both goals in a sustainable climate-resilient manner. It is well-known that past and present genetic and agronomic research results have been key drivers in improving on-farm annual soybean yields improvement from ~1/2 bu/ac per year two decades ago to ~3/4 bu/ac per year more recently.

Aside from production research projects, NSB also funds research projects aimed at improving the constitutive value the NE-grown soybean seed relative to its consumptive & nutritive worth in livestock and aquaculture rations, or in human foods. Moreover, the NSB also funds research projects aimed at developing novel or innovative products that can be manufactured from soybean seed.

I congratulate NSB for carefully reviewing research proposals and their due diligence and conscientious prudence when selecting the most meritorious research proposals to fund each year. For that reason, soybean producers in NE (and elsewhere in the U.S.) will likely be quite interested in reading about the results achieved by NSB-funded research projects described in this booklet.

ADVANCING NEBRASKA SOYBEANS THROUGH RESEARCH

I am Mike Tomes, a soybean producer from Utica, Nebraska, a member of the Nebraska Soybean Board (NSB). In FY23, I served as chairman of the production and crop research committee. The Annual Research Report will provide information on each research project that receives funding from soybean checkoff investments.



Mike Tomes

Production and crop research is currently 27% of the Nebraska Soybean Board budget. Five NSB district directors make up the production and research committee. We discuss the needs of Nebraska soybean farmers which will be addressed through research projects. Ideas and requests brought to the committee for discussion are prioritized, then advanced to the board for approval.

A portion of the Nebraska soybean research investment flows through the North Central Soybean Research Program. This is a group of 13 states which account for 85% of the U.S. soybean production. This collaborative effort is an opportunity for each state to share research dollars in ways that involve the best of researchers who combine their wealth of knowledge to increase soybean quality and production.

I thank the committee members, researchers and advisors who all do their best to help meet our goal of continuous improvement in creating successful soybean production.

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On the Cover: Dr. Justin McMechan presents on the impact of soybean gall midge at the Multi-State Soybean Gall Midge Field Day in July of 2023.

SOYBEAN BREEDING AND GENETICS STUDIES FOR NEBRASKA

CONTRIBUTING ORGANIZATION | Nebraska Soybean Board - \$304,247

LEAD RESEARCHER | George Graef (University of Nebraska–Lincoln)

Our soybean breeding program has three main objectives: (1) we want to improve yield, particularly in Nebraska production environments. (2) protect yield from diseases and pests, as well as from abiotic stresses like drought and high-pH soil that are important issues in Nebraska, and (3) improve seed compositional quality. Our program aims to address important constraints to soybean production for farmers in Nebraska.

For this update, we can highlight our breakthrough in improving seed protein and oil concentration in high-yielding soybeans, and the high level of tolerance to iron deficiency chlorosis in high-pH soils that we have developed over years of selection. From our long-term work with seed composition, we have high-yield lines with a balance of protein and oil that will deliver more than 12 pounds of oil per bushel for the processor and still produce a 48% protein meal.

We have succeeded in creating new soybean lines that have a better balance of seed protein and oil, with no negative effects on yield (Figure 1). Our new lines

meet or exceed the yield of the high-yielding checks that are current cultivars, and most of the new lines have higher seed protein and produce a meal with 48% or more protein. Lines also have a crude oil yield of 11-12 pounds per bushel. We have some lines that yield over 13 pounds of oil per bushel. With new soybean processing facilities planned to be operational in Nebraska in the next 3-5 years, varieties like this could offer additional marketing options and opportunities for increased ROI for producers and processors, with varieties particularly well adapted to Nebraska.

A second area to highlight is our progress with improved tolerance to IDC on high-pH soils. Photos from our test in a field near Fremont in 2023 shows the effects of IDC on average cultivars, showing stunted growth, typical interveinal chlorosis, or more severe symptoms including plant death (Figure 2). Adjacent plots show our tolerant soybean lines under the same conditions. Many lines show no symptoms at all, and have more vigorous growth. Some of these tolerant lines yield as well as the high-yield checks in our multi-location yield trials over years. We are incorporating this high level of

IDC tolerance into our newest and best yielding lines. High-pH soil affects soybean production on millions of acres in Nebraska and neighboring states. Tolerant, high-yielding varieties will increase production and profitability for soybean producers.



Figure 2. Soybean lines in high-pH soil near Fremont, NE, July 2023.

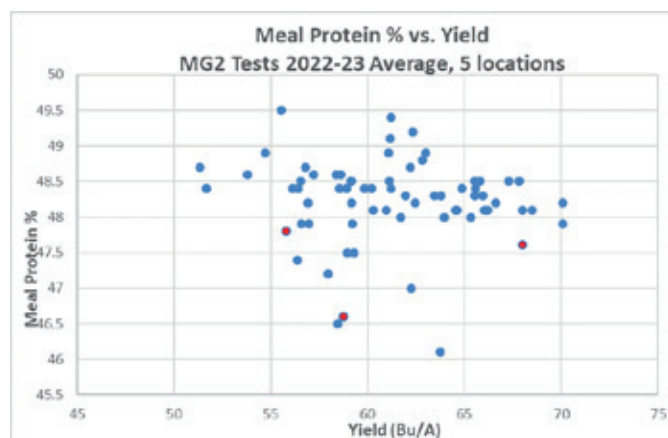
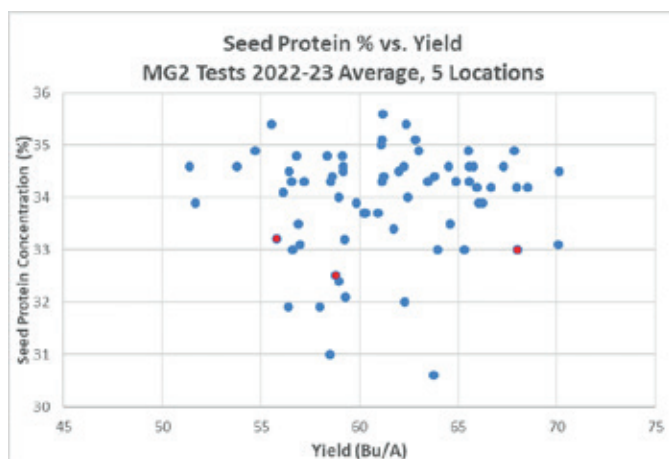


Figure 1. Seed protein concentration vs. Yield, and Meal Protein % vs. Yield for soybean breeding program high-yield lines. The three red points in each graph are the high-yield check cultivars. Blue dots are experimental lines.

EFFECT OF PLANTING GREEN ON RESIDUAL HERBICIDE PERFORMANCE, SOIL HEALTH & MANAGEMENT OF GLYPHOSATE-RESISTANT PALMER AMARANTH IN SOYBEAN

CONTRIBUTING ORGANIZATION | Nebraska Soybean Board - \$54,490

LEAD RESEARCHER | Amit Jhala (*University of Nebraska-Lincoln*)

Planting green refers to no-till planting of the primary crop into actively growing cover crop. Cereal rye is the most planted cover crop in corn/soybean cropping systems in Nebraska. Use of a pre-emergence residual herbicide with multiple sites of action is one of the first recommendations for control of glyphosate-resistant weeds such as Palmer amaranth and waterhemp. Additionally, to be effective, pre-emergence herbicide must be placed in contact with the soil and an even layer of the chemical is required to intercept germinating weed seeds.

The objectives of this study were (1) to determine if planting soybean in standing cereal rye cover crop can suppress Palmer amaranth emergence better compared with early termination, two weeks before soybean planting (BSP), (2) to evaluate effect of planting green on performance of residual herbicides applied pre-emergence for control of glyphosate-resistant Palmer amaranth in soybean, and (3) to evaluate effect of early termination of cereal rye versus planting green on soil health, soybean yield, and cost-benefit ratio for economic analysis.

Field experiments were conducted at Southcentral Ag Lab near Clay Center, Nebraska from 2020 to 2022. Preemergence (PRE) herbicide with two weeks after planting (WAP) termination of cereal rye provided > 95% Palmer amaranth control in 2021 and varied from 88% to 98% in 2022 at 28 d after PRE. A PRE herbicide fb (followed by) late-postemergence (LPOST) herbicide with 2 WAP termination of cereal rye

controlled Palmer amaranth 85% to 92% in 2021 compared with 97% to 99% control 28 d after LPOST herbicide application in 2022. Weed density and biomass were relatively higher with 2 WBP cereal rye termination compared with 2 WAP termination regardless of the herbicide program. PRE fb LPOST herbicide programs integrated with 2 WAP termination of cereal rye reduced Palmer amaranth seed production to less than 9,100 seeds plant⁻¹ in 2021 and no seed production in 2022. Terminating cereal rye 2 WAP was an integral part of Palmer amaranth and giant foxtail suppression, density and biomass reduction, but that it affected soybean yield in 2021 compared with terminating cereal rye 2 WBP, while in 2022, hail and windstorms had a confounding effect on soybean stand and yield.

Both 2WBP and 2WAP reduced N concentration by 48% (31.10 vs 59.70 mg/kg) but had no effect on other soil properties compared with no cereal rye cover crop. Despite the abundant cereal rye biomass production, terminating 2WAP had little to no effect on most soil properties in the short term (3-years). Wet aggregate stability increased as cereal rye biomass production increased, while soil sorptivity (initial water infiltration) increased as wet aggregate stability increased. Cover crop termination timing had inconsistent effects on soybean yield. In general, after 3-years, planting green had no effect on most soil properties or soybean yield, warranting long-term studies on this topic.



Figure 1. Emerging soybean where cereal rye cover crop was terminated 2 weeks after soybean planting. Soybean plant stand and initial growth was not affected when cereal rye was terminated 2 weeks after soybean planting.



Figure 2. The 2 weeks after soybean planting termination of cereal rye treatment provided effective weed suppression, but there was yellowing and stunting of the soybean compared to the 2 weeks before planting termination of cereal rye treatment.

WINTER NURSERY SUPPORT FOR SOYBEAN BREEDING & GENETICS

CONTRIBUTING ORGANIZATION | Nebraska Soybean Board - \$265,692

LEAD RESEARCHER | George Graef (*University of Nebraska-Lincoln*)

The contra-season nurseries in Puerto Rico and Chile provide us with five additional generations per year in our research and development programs. That is a significant benefit for developing populations for research projects and for our variety development efforts.

In the Puerto Rico environment, we use two lighted generations and two unlighted generations from October 1 to June 1. The lighted areas allow good production of F1 plants, crossing block areas, and single plants for specific objectives. In the Chile nursery, our primary use is for progeny rows, growing about 15,000 per season from November to April. The growing environment at the Chile nursery correlates well with Nebraska, so selection for traits important in Nebraska production environments is effective. Plant populations and small increases for research and development programs also occur in Chile to enhance overall program efficiency.

We routinely collect leaf tissue for DNA analysis in our Puerto Rico F1 and crossing block areas, and can do that as needed for specific objectives in the Chile nursery. Overall, the nurseries are invaluable to the success of our research and development programs.



Progeny rows in Chile nursery.



Crossing block area in Puerto Rico nursery.

IMPROVING WATER USE EFFICACY IN SOYBEAN

CONTRIBUTING ORGANIZATION | Nebraska Soybean Board - \$40,000

LEAD RESEARCHER | Katarzyna Glowacka (University of Nebraska-Lincoln)

Research Conducted: In response to the escalating threat of drought conditions in soybean-growing regions, the research conducted by Katarzyna Glowacka and her team at the University of Nebraska, funded by the Nebraska Soybean Board, delves into the potential of genetic modification to bolster soybean crops' resistance to drought stress. Focused on a naturally occurring protein in soybean, the study explores transgenic soybeans that express higher levels of this protein.

Importance: Drought susceptibility during seed setting poses a significant risk, with potential yield losses of up to 30%. As approximately half of Nebraska's soybeans rely on irrigation and the rest on rainfall, the anticipated worsening of drought conditions underscores the importance of developing resilient soybean varieties. The research aims to mitigate yield losses and enhance soybean growth, providing a financial boon for growers in arid years.

Findings: The research team is investigating a genetic modification that manipulates soybean plants' stomatal pores, crucial for water regulation. By tricking the plant into perceiving cloudier conditions, the modified soybeans exhibit reduced water loss while maintaining optimal photosynthetic activity. Preliminary data from small-scale field trials indicate improved growth and seed production under rain-fed conditions.

Benefits/Recommendations: The potential benefits of this genetic modification extend beyond water efficiency, as the research team plans to assess the nutritional content of modified soybeans. As global food demand rises, these genetically modified soybean plants offer a forward-looking solution to ensure stable yields and serve as an insurance policy for farmers against the challenges of evolving climate conditions. The ongoing research underscores the necessity of innovative approaches to sustain and enhance soybean production in the face of changing environmental dynamics.



Pictured is one of Glowacka's team members in one of the experimental plots. The researchers seek to leverage a naturally occurring protein to trick soybean plants into closing their stomatal pores more and retaining more moisture. *Photo: Katarzyna Glowacka.*

SOYBEAN GALL MIDGE: EVALUATING PLANTING DATE AND SEED TREATMENTS

CONTRIBUTING ORGANIZATION | Nebraska Soybean Board - \$54,436

LEAD RESEARCHER | Justin McMechan (University of Nebraska–Lincoln)

Research Conducted: Our objective was to evaluate the impact of five different soybean planting dates at 10-day intervals beginning in late April with or without imidacloprid, a commonly used insecticide seed treatment.

Importance: Soybean gall midge was recently identified as a new species in 2019, and it is a significant soybean pest in Nebraska. Each spring, adults emerge from the previous year’s soybean field and move to the nearest current year’s soybean to lay eggs at the base of the plant. Infestation in soybean requires the presence of small cracks or fissures that occur at the V2 stage about three weeks after planting. As a new species, there is little to no information on the impact of planting date on infestation, plant injury, and yield when significant pressure from soybean gall midge occurs.

Findings: Soybean gall midge adults emerged approximately 10 days earlier than expected in 2023. The early than anticipated emergence significantly increased infestation (Fig. 1) and plant injury (Fig. 2) in late-April and early-May planted soybean compared to the prior year’s study. Even at the maximum labeled rate, imidacloprid (0.23 mg ai/seed) had no significant impact on larval abundance or plant injury. Later plantings in mid-to late-May and early-June had significantly less infestation and injury, likely due to reduced adult activity when fissures or cracks appeared on those planting dates.

Benefits/Recommendations: Although early-planted soybean have the potential for increased yields, they have an increased potential for infestation and injury from soybean gall midge. Yield impacts under heavy soybean gall midge infestations appear to be dependent on when soybean gall midge adults emerge in the spring. If emergence is delayed, soybean development could reach a

stage that lessens the impact on yield. Regardless of yield impacts, growers run the risk of carrying over high populations of soybean gall midge for the following season when soybean is planted early. We recommend that growers plant their

high-risk fields for soybean gall midge last. Imidacloprid as an insecticide seed treatment has had inconsistent results in field studies. This is likely due to the variation in the duration of adult emergence from overwintering sites.

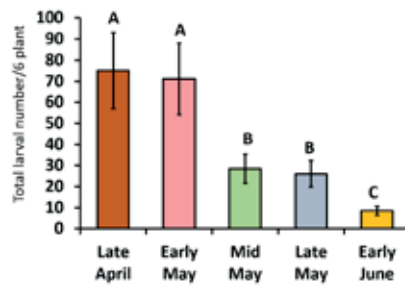


Figure 1

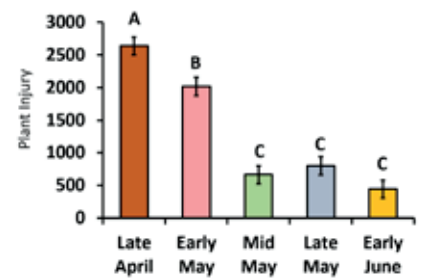


Figure 2



SURVEY AND RAPID DIAGNOSTICS FOR FUNGICIDE RESISTANT FROGEYE LEAF SPOT IN NEBRASKA

CONTRIBUTING ORGANIZATION | Nebraska Soybean Board - \$67,364

LEAD RESEARCHERS | Tamra Jackson-Ziems, Graduate Student Asha Mane (University of Nebraska–Lincoln)

Failure of some fungicides to slow frogeye leaf spot (Figure 1) disease development in some Nebraska soybean fields led to concerns that fungicide resistance was here, too. Numerous other soybean-producing states confirmed widespread resistance to fungicides from Class 11 QoI fungicides – formerly called “strobilurins” and historically among the most effective products for control. With support of soybean checkoff and the Nebraska Soybean Board, a survey was conducted to collect samples of frogeye leaf spot from across Nebraska. With help from Nebraska Extension and crop consultants, 375 samples were collected from 48 counties (Figure 2). The fungus causing frogeye leaf spot, *Cercospora sojina*, was recovered from the leaf samples and tested in the laboratory for fungicide sensitivity with a traditional petri dish test.

Processing and testing using the traditional test is laborious and can have a lengthy wait time for results. With the collaboration of MatMaCorp in Lincoln, Nebraska, additional experiments were performed to develop probes to recognize DNA sequences in the fungus tied to Group 11 QoI fungicide resistance. Samples were ultimately tested with both the traditional and new rapid DNA-based tests, and results agreed - the frogeye leaf spot fungi in ALL of the samples were resistant to Group 11 QoI fungicides. Later fungicide field trials confirmed the lack of effective control when fungicides containing only a Group 11 fungicide active ingredient were sprayed. However, other products, especially those containing a combination of active ingredients (instead of, or in addition to Group 11) from multiple fungicide classes effectively managed frogeye leaf spot.

Frogeye leaf spot can cause up to 60% yield loss when severe in susceptible varieties. Disease severity can be reduced with a combination of crop rotation, disease-resistant varieties and/or spraying fungicides, as needed. Because of these research results, Nebraska producers will know that the frogeye leaf spot in their fields can't be controlled with Group 11 fungicides sprayed alone. Instead, products containing active ingredients from other fungicide classes are necessary to manage frogeye leaf spot. Fungicide ratings for control of diseases can be found by following the QR code and downloading the “Fungicide Efficacy for Control of Soybean Foliar Diseases” publication from the Crop Protection Network website.



Figure 1. Frogeye leaf spot lesions on a soybean leaflet.

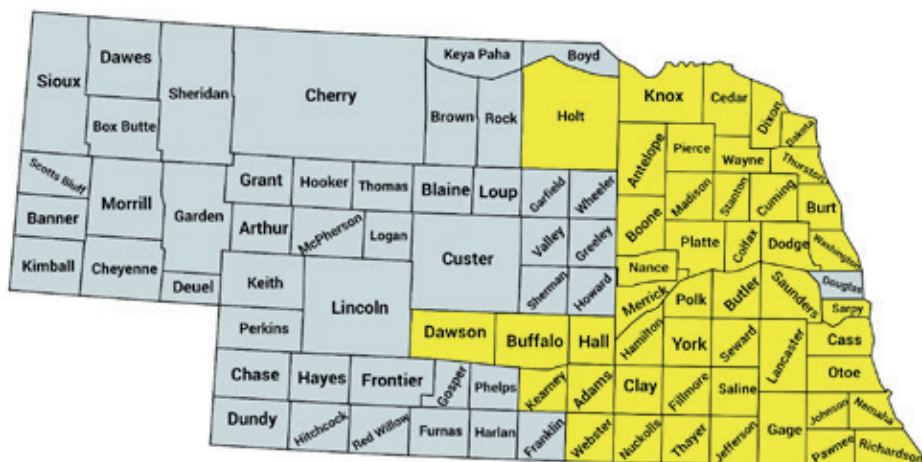


Figure 2. Frogeye leaf spot resistance to Group 11 QoI fungicides (formerly called strobilurins) was confirmed in 48 of Nebraska’s soybean-producing counties (yellow).



If you have questions about managing this or other soybean diseases, contact Dr. Dylan Mangel or others in Nebraska Extension.

TEASING APART THE GENETIC COMPLEXITY OF SOYBEAN SEED DEVELOPMENT

Empowering Nebraska Soybean Farmers with Cell Level Information

CONTRIBUTING ORGANIZATION | Nebraska Soybean Board - \$27,754

LEAD RESEARCHERS | Marc Libault, Qiuming Yao (*University of Nebraska-Lincoln*)

Research Conducted: To unravel the intricate genetic programs governing soybean seed development, Dr. Libault and Dr. Yao’s research project focused on the precise characterization of the activity of the soybean genes in each cell composing the plant, on the establishment of comprehensive gene networks at the single cell level, and the exploration of key transcription regulators influencing soybean seed development. To reach this objective, Dr. Libault utilized the most cutting-edge single cell technology to dissecting the activity of soybean genes within each single cell and single cell type comprising the plant including seeds at different developmental stages. These efforts were driven by the aim to contribute to the advancement of soybean genomics, genetics, and the upcoming implementation of targeted genetic engineering approaches to increase overall selected traits including yield.

Importance: The research is of utmost importance to Nebraska soybean farmers as it delves into the very core of soybean yield, i.e. seed development, and support the development of new targeted approach based on the engineering of genes. By unraveling the genetic intricacies that underlie soybean seed biology, scientists will gain valuable insights into optimizing crop

management strategies. This newfound knowledge empowers scientists to make informed decisions that directly impact soybean yield and the quality of their harvest.

Findings: Our research has successfully identified soybean genes specifically expressed in each cell type composing the soybean plant; including seed cell-type-specific soybean genes. Additionally, we uncovered temporal changes in gene activity throughout the seed development process. We also use the most current web technology and information science to display the discovery in public resource to drive open source and potential collaboration of the soybean research community. The entire findings and products from this project not only deepen our understanding of soybean seed biology but also provide a foundation for future innovations in soybean breeding and cultivation practices.

Benefits/Recommendations: The outcomes of this research present multi-

aspect benefits for Nebraska soybean farmers. The identification of seed-specific soybean genes and the revelation of their temporal expression patterns offer crucial insights for strategic crop engineering and to secure the future of soybean yield. Armed with this knowledge, scientists will be able to implement targeted optimizations of soybean cell biology notably during key developmental stages, thereby optimizing yield and enhancing overall crop quality. This research program will also generate recommendations for producers include integrating the newfound genetic insights into breeding programs to maximize soybean yield. Furthermore, the establishment of the “Soybean Single Cell Transcriptome Atlas” provides a cutting-edge online resource for farmers and researchers alike. This dynamic platform serves as a hub for exploring the intricate details of soybean seed development, fostering collaboration, and facilitating informed decision-making within the agricultural community.

soybeancellatlas.org

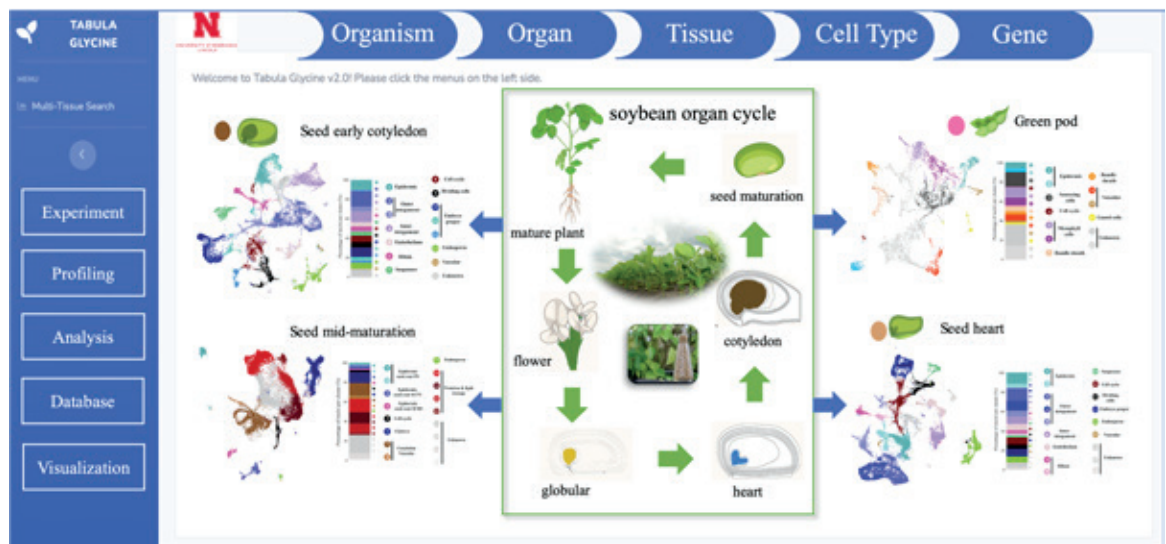


Figure: Empowering scientists and farmers, the soybean cell atlas is an innovative online resource providing a detailed, single-cell resolution visualization of soybean gene activity. In addition to offer a new perspective on gene expression, this unique digital resource represents a valuable tool for optimizing genetic engineering strategies and agricultural practices.

RESEARCH ON SOYBEAN OIL AS A SUSTAINABLE RECYCLING AGENT

CONTRIBUTING ORGANIZATION | Nebraska Soybean Board - \$91,782

LEAD RESEARCHER | Hamzeh Haghshenas Fatmehsari (University of Nebraska–Lincoln)

Using old asphalt in new roads is challenging because the old material doesn't hold up well. Engineers have tried different ways to fix this, like using special agents made from things like oil to make the old asphalt work better. Now, they're trying to make this process more eco-friendly by using oils from plants, like soybeans. In this study, we used crude soybean oil (CSO) to make a mix that contains 65% old asphalt like a new asphalt. We added another substance called an antioxidant (ZnDEC) to stop the soybean oil from getting old too fast. We then tested how strong this mix was against cracks, bumps, and damage from water.

Figure 1 shows that using CSO made the old asphalt better at resisting cracks, but it wasn't as good as completely new asphalt. However, the mix with CSO didn't break down as fast as mixes with either all-new or 65% old asphalt. After a long time, the CSO mix was even better at resisting cracks than the mix with 65% old asphalt. It was also better at handling bumps and water damage compared to the 65% old asphalt mix, while still being similar to the all-new asphalt in handling bumps. ZnDEC, the antioxidant used in this study, made the old asphalt mixes with CSO last longer without getting old too quickly. It didn't really change how well the road handled getting bumpy or getting damaged by water. We also checked how these asphalt mixes affected the environment and their cost over time. It turns out that using CSO and ZnDEC in the mix is not bad for the environment and saves money in the long run.

Using old asphalt in roads has many benefits for society. For example, in Nebraska, the Nebraska Department of Transportation (NDOT) wants to use a lot of old asphalt, about 65%, in the roads. Our tests show they will need to add about 3.5% of CSO to the old asphalt to make it work. With Nebraska making around 2 million tons of asphalt every year, if they use 65% old asphalt, they will need to add about 3,850 tons of CSO just for NDOT projects. That's likely double the amount needed for all road paving in Nebraska.

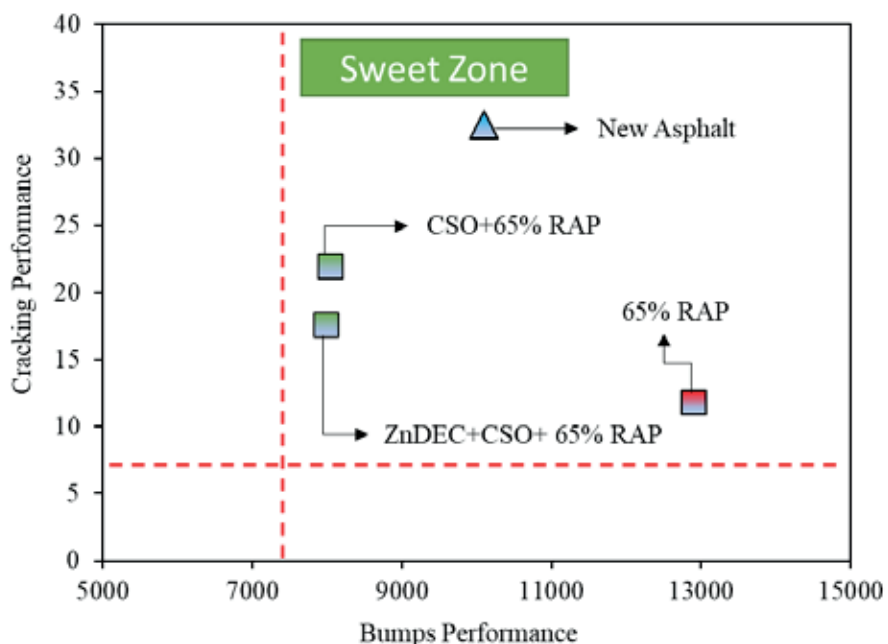
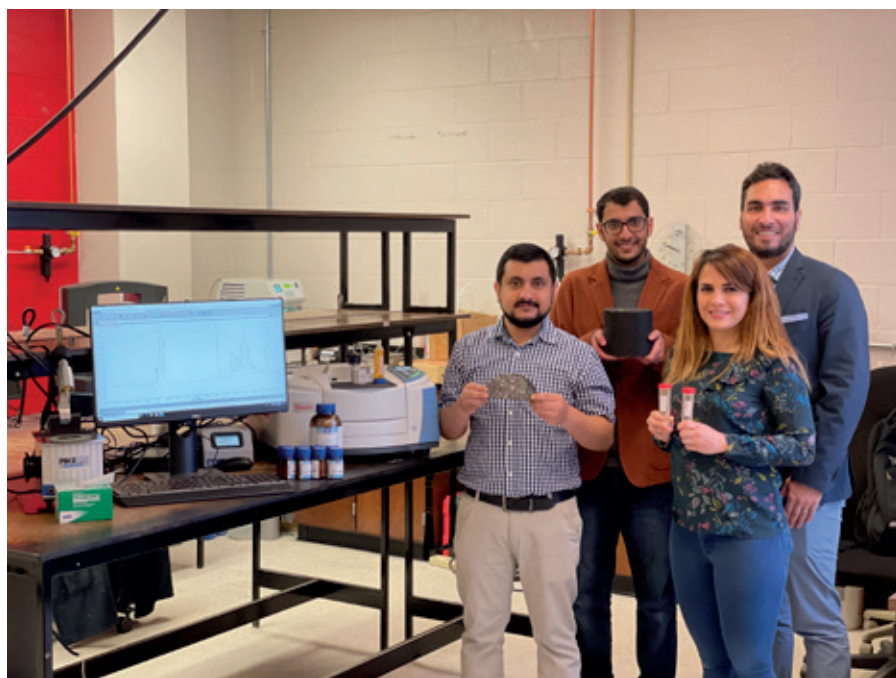


Figure 1. Performance diagram of asphalt mixtures evaluated in this project.



UNL's Dr. Hamzeh Haghshenas (far right) and the team of Nebraska researchers and engineers working on the asphalt project.

ENHANCING SOYBEAN GERMPLASM THROUGH BIOTECHNOLOGY

CONTRIBUTING ORGANIZATION | Nebraska Soybean Board - \$132,925

LEAD RESEARCHER | Thomas Clemente (*University of Nebraska–Lincoln*)

Research Conducted: This program is adding novel genetic variation to soybean through the introduction of transgenic and/or edited alleles to address both input and output traits in the crop. Regarding the former, genetic approaches are being investigated to improve harvest index and impact resistance to the soybean gall midge. As per the latter, various genetic strategies are being tested for their impact on changes in seed reserve content (protein/oil/starch) and designing a better bean for direct food applications.

Importance: This research program follows the ‘build-test-learn’ model, wherein genetic designs are ‘built’ based off previous research findings. The genetic designs are then introduced into soybean employing the tools of biotechnology, and the derived soybean linages carry the novel genetic variation are ‘tested’ under controlled and field-based environments.

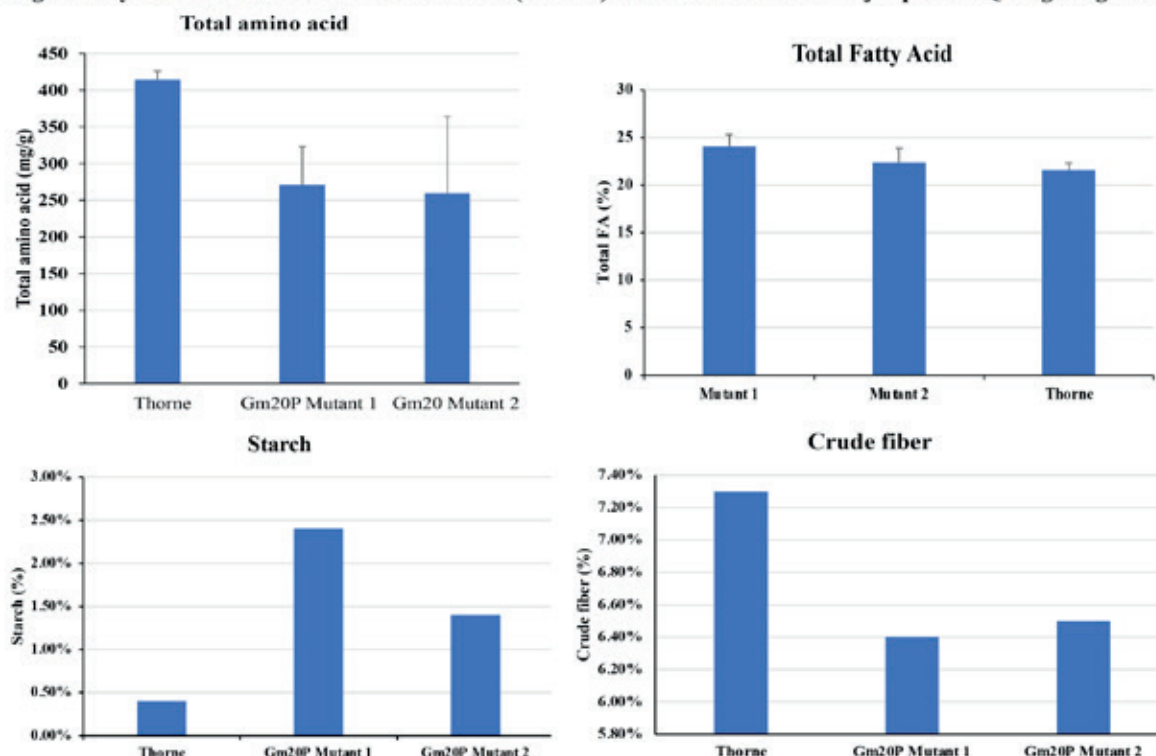
The ‘learn’ step assesses data gathered during the test phase, which helps inform improvements on future genetic designs to test, and importantly helps guide soybean breeding programs on genetic alleles to introgress for traits that hold potential for gains in yield, protection of yield and quality improvements in the harvest.

Findings: The outcomes during the past fiscal year including the identification of the three soybean events carrying an insect resistance allele from rice that may hold promise towards gall midge resistance. Seeds of these are being bulked for testing in the field in the 2024 season. Secondly, data was gathered on soybean lines that carry edited alleles in soybean genes that influence seed reserve content. One such gene that was edited is the soybean gene model that underlies a major protein QTL. Soybean lines carrying edits in this gene, display a significant drop in

total protein (<30%) with no change in total oil and an increase in total starch content. Moreover, under field environments an observed delay in maturity occurs, with no negative impact on plot seed harvest. Studies are now under way to help elucidate the mechanism by which this gene has such a major impact on soybean seed reserve content.

Benefits/Recommendations: The benefits from investments in such research is the information learned from such investments is returned through translational outcomes from soybean breeding programs. Which are the key driver for the continuous improvement in germplasm that contribute to soybean producers’ economic sustainable cropping systems through genetic gains in yield, protection of yield and quality of the harvest.

Changes in soybean seed reserve content in control (Thorne) vs edited mutants in major protein QTL gene grown in the field



IMPROVEMENT OF SOYBEAN GERmplasm FOR AQUACULTURE FEED

CONTRIBUTING ORGANIZATION | Nebraska Soybean Board - \$73,948
LEAD RESEARCHER | Ed Cahoon (University of Nebraska-Lincoln)

This project aims to develop soybean germplasm with oil quality traits optimized for high value soy-based aquaculture feeds, one of the most significant new markets for Nebraska soybean producers. Limiting the use of soybean oil for aquaculture feed is its lack of EPA and DHA omega-3 fatty acids needed for heart-healthy fish oils. Also missing in soybean oil is the carotene-related pigment astaxanthin that is needed for the red color of shrimp and salmon flesh. To solve soybean oil's deficiency of EPA and DHA, we obtained genes from algae and other organisms that naturally produce these fatty acids.

We worked with the University of Nebraska-Lincoln Plant Transformation Core Research Facility to insert up to six of these genes into soybeans. The engineered lines have been selected over several generations in the greenhouse for their production of EPA and DHA seed oil and advanced to field testing at the Eastern Nebraska Research, Extension and Education Center in Mead, NE. Soybean lines have been identified with seed oil containing EPA to >10% and a combined 3% DHA/5% EPA. While these levels are high enough for commercial use, our current challenge is to improve the agronomic fitness of the seeds. We are also currently pursuing collaborations with animal scientists to explore the use of the omega-3 soybeans in specialty livestock feeds.

In addition, we have used results from Nebraska Soybean Board funding to obtain a grant from the USDA to develop soybeans that produce high levels of astaxanthin that result in red seeds. Astaxanthin is one of the most expensive feed components for farm-raised salmon and shrimp that creates the consumer-desired red color. We obtained genes from the ornamental plant *Adonis* that produces red flowers with naturally high astaxanthin content. We have introduced these genes into a model oilseed crop and obtained seeds that are highly enriched in astaxanthin, without any negative effects on crop and seed fitness. We are pursuing patent protection for this exciting technology and are now introducing these genes from *Adonis* into soybean. As our research continues to advance, we anticipate the development of high-value soybean germplasm that can supply multiple market streams for soy-based aquaculture feed. The expanded use of soybean oil for aquaculture, beyond the current demand for meal, will translate into increased profitability per acre for Nebraska soybean producers.



Figure X. Production of astaxanthin in soybean for high-value aquaculture feed components. Shown are non-engineered 'Thorne' soybean seeds (left) and soybeans engineered for astaxanthin production.



Figure X. Field testing of aquaculture soybeans at the Eastern Nebraska Research, Extension and Education Center in Mead, NE.

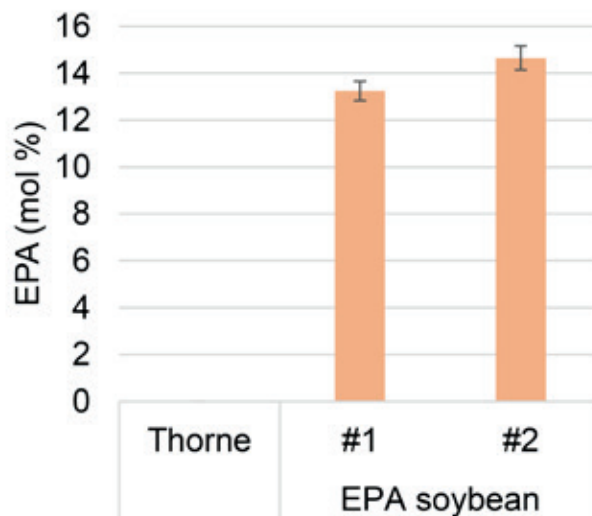


Figure X. Production of soybean oil enriched in omega-3 EPA for enhanced aquaculture feed. Shown is the EPA content of non-engineered 'Thorne' soybean seeds and two soybean lines engineered for EPA production.

ASSESSING THE GENETIC DIVERSITY AND VULNERABILITY OF NEBRASKA SOYBEAN

CONTRIBUTING ORGANIZATION | Nebraska Soybean Board - \$62,036

LEAD RESEARCHER | David Hyten (*University of Nebraska–Lincoln*)

Research Conducted: The focus of this project is to create a better understanding of the genetic diversity within the UNL breeding program by sequencing key germplasm from the program. This includes historical lines, germplasm lines, released cultivars, and parents of current breeding lines within the program. The objectives of the study are to identify regions of the soybean genome which have low genetic diversity in the UNL soybean breeding program, identify potential germplasm from the USDA germplasm collection that could be used to decrease this vulnerability of low diversity, and to identify which regions of the soybean genome breeders have been actively selecting to identify strategies that could be used to help maintain genetic diversity around these regions.

Importance: Maintaining genetic diversity within the breeding program is crucial for the sustained improvement of soybeans in Nebraska. This research lays the foundation for understanding the genetic diversity present in the state’s soybean germplasm and how selection practices impact that diversity. Genetic gain and yield potential directly correlate with the genetic variability in the population. Identifying novel diversity that complements the elite background is essential for future improvements and the enduring success of the Nebraska soybean breeding program.

Findings: Our recent findings reveal key insights into the genetic makeup of Nebraskan soybean breeding lines. Genomic regions associated with maintaining stable yield across environments display varying levels of relaxed directional selection compared to the rest of the genome. Notably, environmental influences play a significant role in genetic variance for soybean grain yield. Our results will be used as a roadmap

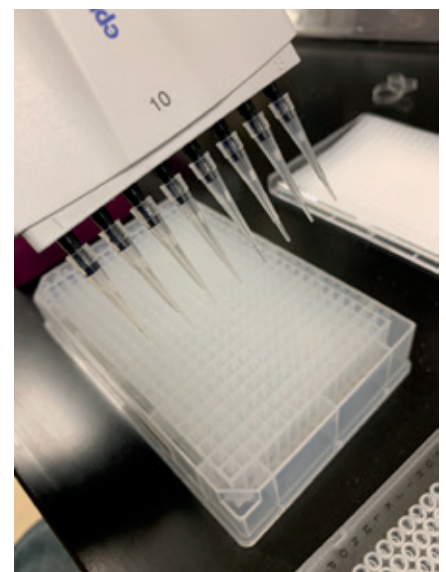


Diverse soybean lines from the USDA germplasm collection and the University of Nebraska that were grown out for DNA extraction followed by complete genome resequencing.

to identify new germplasm that brings in novel genetics for soybean improvement. This newfound understanding of the genetic architecture of soybean diversity in the breeding program will enable breeders to select new parental lines more effectively, aiding in boosting genetic gain.

Benefits/Recommendations: Introducing Novel Diversity: Our research emphasizes the importance of identifying lines that are most likely to incorporate novel diverse germplasm to counteract low diversity vulnerabilities in the breeding program.

Identifying Regions of Positive Selection: Identifying genomic regions under positive selection is crucial. Selecting for these regions while incorporating diverse germplasm is vital for local adaptability of new cultivars developed from diverse germplasm. In conclusion, our ability to identify novel diversity that can complement the adapted soybean elite parental background can be used for future improvement to ensure the long-term success of the Nebraska soybean breeding program.



DNA was then extracted from leaves in multiwell plates and sequenced.

DEVELOPING AN APPROACH TO GUIDE NITROGEN FERTILIZER APPLICATION IN SOYBEAN

CONTRIBUTING ORGANIZATION | Nebraska Soybean Board - \$86,980

LEAD RESEARCHER | Patricio Grassini (University of Nebraska–Lincoln)

At present, there are no explicit guidelines on nitrogen fertilizer application in soybean. The team led by UNL Professor Patricio Grassini and Assistant Professor Nicolas Cafaro La Menza, is working to develop recommendations on nitrogen fertilizer application for Nebraska’s soybean farmers. Over the past two years, the team has conducted 35 trials in farmer soybean fields across the state. In each field, the researchers have evaluated the yield response to nitrogen fertilizer application and assessed different methods to predict the yield response so that farmers can determine in which cases a nitrogen fertilizer application should be considered.

The nitrogen limitation in high-yield soybean crops is well documented. “Soybean plants source nitrogen from the soil through the roots and also from the air through a process called biological fixation”, says UNL PhD student Luzviminda Sazon, who has led the field experiment and is working on analyzing the data. “However, the nitrogen that comes from the soil and biological fixation is not sufficient to meet the plant nitrogen demand, especially in highly productive irrigated soybeans that are planted early and receive good management”, adds Luzviminda.

However, the means to overcome the nitrogen limitation are not clear. “When you apply nitrogen fertilizer in soybean, there is a parallel reduction in the amount of nitrogen fixation, resulting in a lack of yield response to the added nitrogen fertilizer and a profit loss”, says Assistant Professor Nicolas Cafaro La Menza. The UNL team found, however, that a relatively small amount of nitrogen fertilizer around flowering, guided by the nitrogen status of the crop at that time, could lead to a consistent and profitable yield response. “It has been a long road, but we believe we are getting close to a recommendation for cost-

effective nitrogen application in soybean in Nebraska”, says Dr. Cafaro La Menza.

At the end of the day, the project will generate a practical tool that will help Nebraska producers identify soybean fields where applying N fertilizer can lead to a profitable yield response. “Our average yields increase year after year due to agronomic and genetic

improvements”, says UNL Professor Patricio Grassini. “Since we know that plant nitrogen requirements also increase with higher yields, overcoming the nitrogen limitation in soybean in a cost-effective and environmentally sound way, will be crucial to support further yield gains in Nebraska and the country and this project is contributing to these goals”, says Dr. Grassini.



Drone image



Taking a clipping



Flags mark the test plants

TRACKING THE SEVERITY, FREQUENCY, AND HOSTS OF SOYBEAN GALL MIDGE

CONTRIBUTING ORGANIZATION | Nebraska Soybean Board - \$48,606
LEAD RESEARCHER | Justin McMechan (University of Nebraska–Lincoln)

Research Conducted: Our objective was to conduct a field survey to evaluate the presence, abundance, and plant injury from soybean gall midge in Nebraska and establish a database to determine any weather or management related factors for increased risk. In addition, the larvae from these fields would be analyzed for any genetic differences.

Importance: In 2018, soybean gall midge emerged as a significant pest of soybean and was initially found in 65 counties in the Midwest. As of 2023, larval presence of the pest has been documented in 164 counties across 7 states in the Midwest. Of the total counties infested, 50 are in Nebraska, accounting for 80% of all soybean acres in the state. Field observations over the past couple of years show considerable variability in infestation and plant injury from soybean gall midge, raising questions about what factors are responsible for the increased risk of soybean gall midge in certain areas.

Findings: Of the 56 counties surveyed, 42 had soybean gall midge larvae based on a random field survey in 2023, with 23 of those counties having an elevated larval presence (Fig 1). Plant injury was found in 24 counties, with 11 counties having elevated levels of plant injury. An analysis of the landscape around these randomly sampled fields shows that the sample’s proximity to dense vegetation, distance from the prior year’s soybean field, and the proportion of soybean in the area the previous year are among some of the key factors for increased larval presence and plant injury.

Benefits/Recommendations: None of the risk factors identified to date are easily altered by growers; however, these factors help identify fields at greater risk of infestation and injury from soybean gall midge. To date, the most effective management tactics for soybean gall midge

are applied before pest presence. Growers can use the risk factors identified in this field survey and the historical knowledge of the field to make an informed management

decision. In addition, the information collected from this survey has helped improve the scouting process for new county detections.

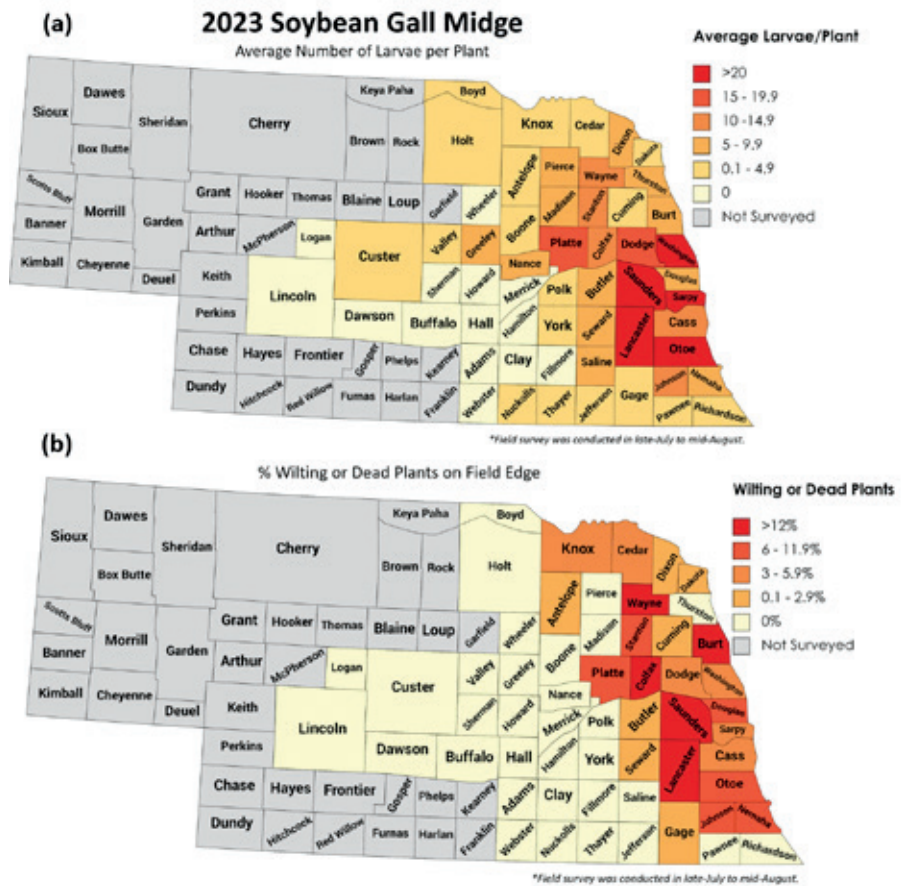


Figure 1



USING DATA INTEGRATION APPROACH TO BREAK GENETIC CEILINGS OF QUALITY OIL ACCUMULATION

CONTRIBUTING ORGANIZATION | Nebraska Soybean Board - \$57,000

LEAD RESEARCHER | Chi Zhang (University of Nebraska-Lincoln)

Research Conducted: We studied the effects of transgenic alleles on soybean events with the goal of increasing seed quality oil accumulation using the build-test-learn paradigm. To achieve this goal, a comprehensive understanding of the pathways regulating oil synthesis in transgenic soybean lines and a strategy to overcome genetic constraints were obtained by using a systems approach to mine the enormous transcriptome data. Research on these differential gene calls will direct the development of constructs that can overcome the genetic ceiling that may be limiting the accumulation of oil, especially omega-3 fatty acids.

Importance: Discoveries on key genes will pave the way for genetic engineering solutions that can alter linked systems and overcome hereditary limitations. We are now conducting research on soybean fatty acid synthesis that aims to generate soybeans with a high oil content and oil quality by directly uncovering connections among genes involved in carbon partitioning processes. In certain industries, such as the aquaculture feedstock market, this might have a major influence on the soybean business in the U.S. and throughout the world. Furthermore, this effort will pique the curiosity of researchers, and the comprehensive carbon capture and partitioning routes may then direct functional investigations across the genome to the phenome.

Findings: Gene expression data were analyzed after acquisition of over 130 transgenic and wild-type soybean samples. Our study primarily involved the comparison of three distinct varieties of transgenic soybeans. Arabidopsis-translated genes AthWRI1 and AthDGT1 are in Type (1). Type (2) overexpresses soybean-derived genes GmWRI1 and GmDGT1. Type (3) has two transplanted DHA+Tocopherol genes. Because Type (2)

has more oil buildup, we compared Type (1) and Type (2) to find the causes. Soybean Type 3 is distinguished from other soybean varieties by its elevated concentration of DHA omega-3 fatty acid. By employing our system approach, we successfully identified some key genes that are regulated by GmWRI1 but not AthWRI1. These genes have capability to promote a more pronounced accumulation of oil.

Benefits/Recommendations: The research team led by Dr. Thomas Clemente is utilizing these identified candidates to develop novel transgenic soybeans capable of exceeding the omega-3 fatty acid accumulation limit. It is anticipated that the newly developed transgenic soybeans will accumulate omega-3 fatty acids EPA and DHA in excess of 9%.

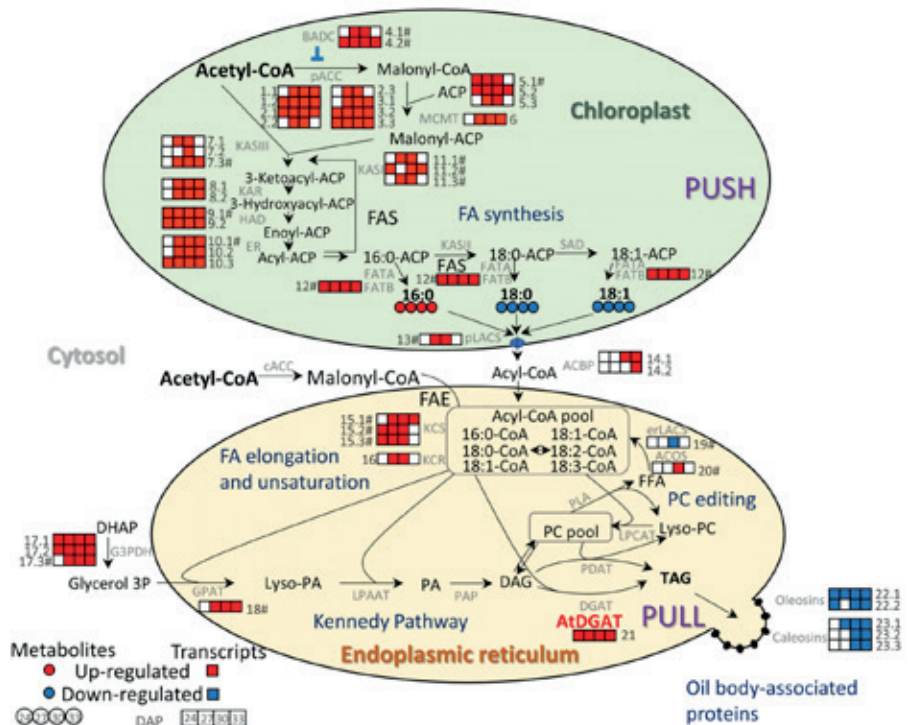


Photo credits: "Arias et al. (2021) Plant Biotechnology Journal"

BIOHYDROLYSIS OF SOYBEAN TO IMPROVE LIVESTOCK FEED AND BIODIESEL PRODUCTION

CONTRIBUTING ORGANIZATION | Nebraska Soybean Board - \$33,728

LEAD RESEARCHERS | Paul Blum & Nicole Buan (*University of Nebraska–Lincoln*)

Research Conducted: In this project we tested the benefit of adding an Extremase enzyme processing step to determine if enzyme treatment would increase oil and soluble sugar recovery from dry soybeans intended for biodiesel or animal feed (Figure 1). Soybean carbohydrates can be broken down into their component sugar monomers by enzymatic treatment in a process called biohydrolysis. Extremase has potential to improve the digestibility of soybean carbohydrates to increase its nutritive value while simultaneously improving fractionation of oil from carbohydrates for biodiesel production.

Importance: In the U.S., over 4 billion bushels of soybean are produced every year. Of this, 70% is used as animal feed, and about 5% is used to make the renewable fuel biodiesel. Dry beans are used directly as animal feed because they are composed of proteins, oil, and carbohydrates. For biodiesel, soybean seeds are processed to separate oil and the remnant protein and carbohydrates are used for animal feed. Non-soluble carbohydrate polysaccharides are the most common sugars found in soybeans and sugar solubility affects digestibility in livestock. Enhanced recovery of oil, fermentable sugars, and improved digestibility and nutritive value of soy residuals would increase the value of soy crops for fuel and feed.

Findings: Our research shows Extremase treatment results in increased oil recovery from soybeans and release of sugars for subsequent ethanol or other fermentation processing (Figure 2). Degree of oil recovery varied depending upon the soybean processing method used. Coarse ground, acid and Extremase treated soybeans showed the greatest increase in liberated oil (6.8 fold) over the no enzyme control while fine ground, acid and Extremase treated soybeans yielded a

2.4 fold increase of oil recovery compared to when enzyme was omitted (Figure 2a). The composition of the oil profile was analyzed using gas chromatography and no significant difference was found in the profile of the lipids released with Extremase compared to mechanical extraction. This demonstrates that the use of Extremase increases the yield of oil without changing the composition of the soy lipids. Total sugar yields were

also increased with Extremase digestion (Figure 2b). Using Extremase, 59.47% of the theoretical maximum of sugar was released from the soybeans which is a 12.6 fold increase over soybeans processed without enzyme.

Benefits/Recommendations:

Extraction of soy oil or soy sugars for biofuel fermentation or animal feed is significantly enhanced by use of treatment with Extremase enzymes.

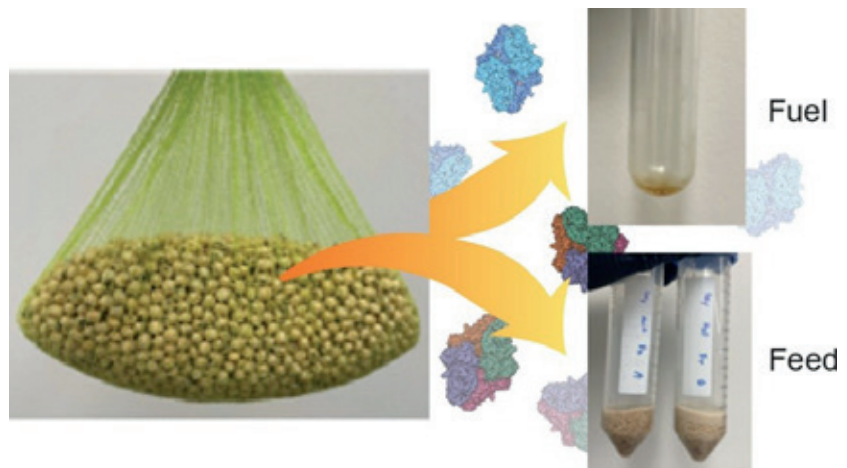


Figure 1. Project summary. Soybean treatment with enzymes was tested for the effect on oil and sugar extraction.

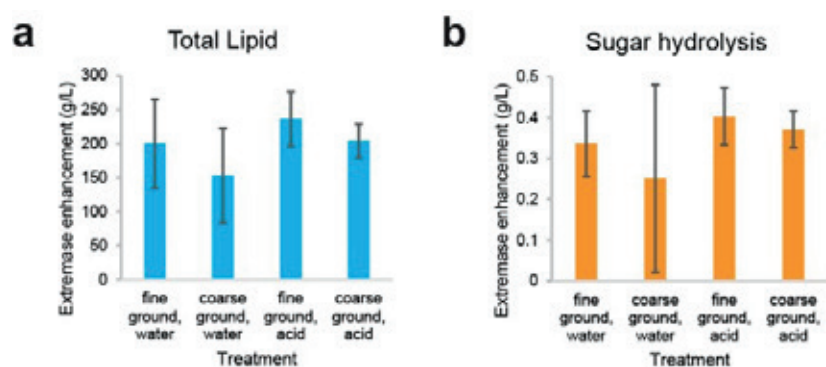


Figure 2. Extremase enhances recovery of oil and sugar from dried soybeans. Panel a, use of Extremase enzymes resulted in higher lipid yields from finely or coarse-ground soybeans whether water or acid pretreatment was used. Panel b, Extremase also resulted in higher concentration of sugar reducing ends indicating more carbohydrate depolymerization of soybeans.

EFFECTS OF USING SOYBEANS, ROASTED SOYBEANS OR SOYBEAN MEAL IN FEEDLOT DIETS

CONTRIBUTING ORGANIZATION | Nebraska Soybean Board - \$51,769

LEAD RESEARCHER | Pablo Loza (*University of Nebraska–Lincoln*)

Since the expansion of the ethanol industry in the early 2000's and the resulting increment in distillers grains supply, very little effort has been made to evaluate other protein sources in current feedlot diets. Disruptions of distillers grains supply during 2020, and a scarcity of these byproducts in some feeding areas are creating more opportunity for using soybean and soy byproducts in cattle feeding. In 2022, the Nebraska Soybean Board granted a team of UNL researchers funds to perform a series of trials to evaluate the effects of using soybeans and soy byproducts in feedlot diets. The first experiment, currently in progress, is comparing different inclusion levels of whole raw soybeans, roasted soybeans, soybean meal and distillers grains. With 56 pens (8 pens/treatment), researchers are evaluating seven different diets. Two of those diets include whole (untreated) soybeans at two different inclusion levels, two other diets using roasted soybeans at the same levels, and the remaining three treatments using soybean meal, distillers grains and a control diet where urea is the crude protein source.

In a second experiment that will be started this coming May, a more deep and detailed analysis of the ruminal behavior of soy protein will be performed. This trial will be conducted in the new Klopfenstein Individual Feeding facility at Eastern Nebraska Research Extension and Education Center near Mead, NE.

Following these two experiments, a third experiment will compare soybeans (roasted and raw) and soybeans byproducts at equal levels of protein inclusion in the diets.

Project Benefits:

- ▶ Increasing the use of soybean meal or raw or roasted soybeans, in feedlot diets would generate an increased market share for soybeans.
- ▶ Replacing distillers grains with soybeans may be an economically viable alternative, especially for small or medium sized feedlots that might struggle to source distillers grains but have local access to soybeans.
- ▶ Crop producers understand the agronomic benefits of incorporating soybeans into the crop rotation and many small to medium sized feedlot operators also control crop acres.
- ▶ Increasing soybean inclusion in feedlot diets would benefit both the cattle and crop operations for these producers.
- ▶ Increasing the use of soybeans close to primary crop growing areas could increase soybean demand and crop area in the long term.



A COMPREHENSIVE PLAN FOR SCN EDUCATION IN NEBRASKA

CONTRIBUTING ORGANIZATION | Nebraska Soybean Board - \$33,010

PRIMARY EXTENSION EDUCATOR | Dylan Mangel (University of Nebraska–Lincoln)

Research Conducted: Soybean cyst nematode (SCN) is the number one yield limiting pest of soybeans. However, it often goes unnoticed because it rarely causes noticeable above ground symptoms. The purpose of this Extension project was to increase recognition that SCN is a yield-limiting problem in grower fields, and to increase identification. Once SCN is identified, which is likely due to its spread across Nebraska, the second objective is to Educate farmers and agronomic professionals how to implement appropriate management practices to reduce the impact of SCN and improve their profitability.

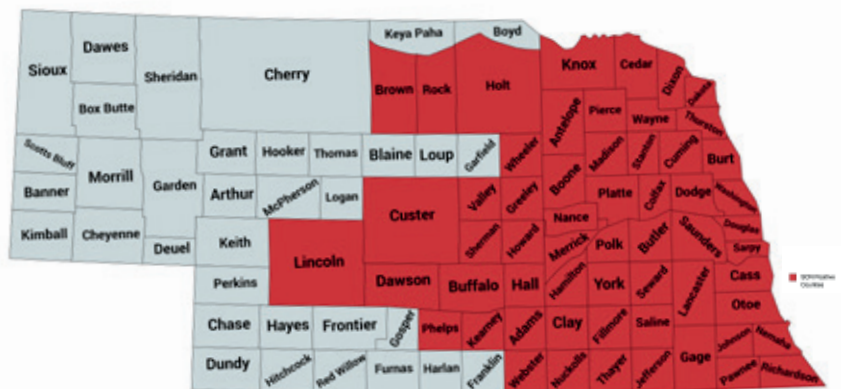
Importance: This project provides necessary opportunities for face-to-face communication about the principles of the soybean cyst nematode pathosystem to Nebraska producers. The information shared in this outreach is direct identification and management recommendations that help producers know when a management investment will be profitable. The SCN testing program saves producers money by improving the accessibility to testing, which is the only way to accurately identify this pest. After identification of SCN, continued testing of infested fields is the best way to determine if management is working. Through this program, we have identified new counties with fields that have tested positive for SCN and are able to map the growing distribution of SCN throughout Nebraska. This program helps us direct information directly where it is needed.

Findings: This grant helps producers identify SCN in their fields and allows us to be the first line of contact to provide unbiased information about active management. This project identified SCN in 38% of 584 samples submitted to the program in 2023. The counties with the highest rate of positive samples were

Burt, Antelope, Polk, and York, ranging from 72.7% to 66.3% positive. The highest egg counts were found in Platte, Antelope, Madison, Buffalo, and Cass counties, with the highest being 22,960 eggs/100cc soil.

Benefits/Recommendations: Each sample submitter receives a report and management guidelines for their results. General results, protecting individual's specific data, were included in articles in CropWatch, Market Journal, radio, and

in news releases and other educational programs across the state. These results are also shared at field days where we interacted with producers and consultants that represent significant Nebraska acreage. These platforms are used to indicate to producers that SCN is a problem anywhere present and that active management is the only current solution while new technologies and resistance sources are researched and developed.



EVALUATION OF PRECISION PLANTING TECHNOLOGIES & DIGITAL TOOLS ON SOYBEAN PRODUCTION

CONTRIBUTING ORGANIZATION | Nebraska Soybean Board - \$19,000

PRIMARY EXTENSION EDUCATORS | Bruno Patias Lena, Luan Pereira de Oliveira, Nate Dorsey
(University of Nebraska-Lincoln)

This research project conducted during the 2023 soybean season in eastern Nebraska aimed to assess the influence of different planter downforces and speeds on soybean production. The study focused on downforces of 100, 150, and 200 lbs, and speeds of 5, 7.5, and 10 mph, with a control check at 0 lb downforce + 5 mph. A 16-row ExactEmerge John Deere planter equipped with the John Deere IRHD hydraulic downforce system was used. The evaluation included key parameters such as soybean emergence, stand counts, and yield.

Farmers still face challenges related to choosing optimal downforce loads and planting speeds, and this study directly addresses these concerns. Planter settings are one of the many factors influencing good seed-to-soil contact, seed germination, emergence, and final stand, ultimately impacting crop outcomes. The findings of this project offer practical recommendations that, when implemented, can lead to improved crop emergence, uniform plant populations, and increased soybean yields.

The study revealed significant insights into row-unit bounce and ground contact, crucial factors to achieve a better seed-to-soil contact. Row-unit bounce was minimized at 5 mph, regardless of downforce loads, highlighting the importance of moderate speeds. Ground contact, essential for seed-to-soil contact, was influenced by downforce and speeds. Moreover, larger downforces increased ground contact, while faster planting speeds reduced ground contact (Figure 1).

Emergence Velocity Index, indicating plant emergence speed, remained unaffected by downforce and speeds. However, plant population varied, with notable impacts at 100 lbs downforce and 5 mph speed. Optimal downforce loads (200

lbs) exhibited lower variability in plant population, showing that is a good option to sustain consistency during planting.

Even though variations on row-unit bounce were found on different downforce and speeds, and there was an increased trend of Emergence Velocity Index, no significant differences were observed in soybean yields (Figure 2). This resilience of soybeans to compensate for population variations show the robustness of soybean production, providing farmers with flexibility in

managing planting conditions without compromising final crop yield.

Hence the acquired results, the study suggested that planting at speeds near 5 mph is the best option to minimize row-unit bounce. Additionally, larger downforce loads (200 lbs) could result in better seed-to-soil contact and lesser variability in plant population. These insights can serve as guidance for farmers seeking to optimize their planting practices for improved soybean production.

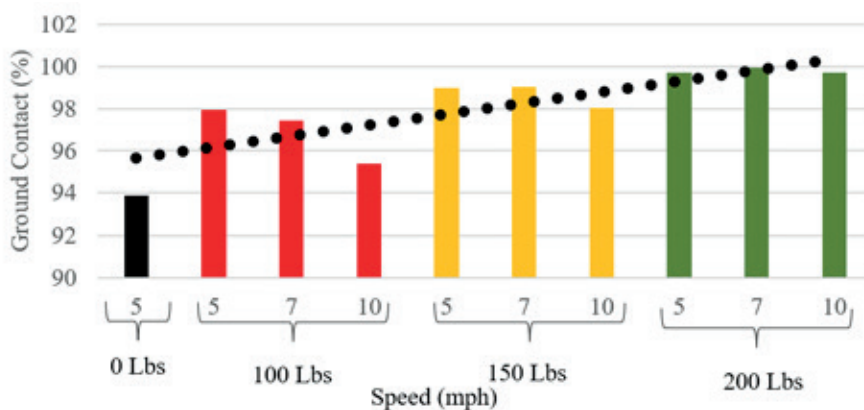


Figure 1. Planters' ground contact submitted to different Speeds and Downforces

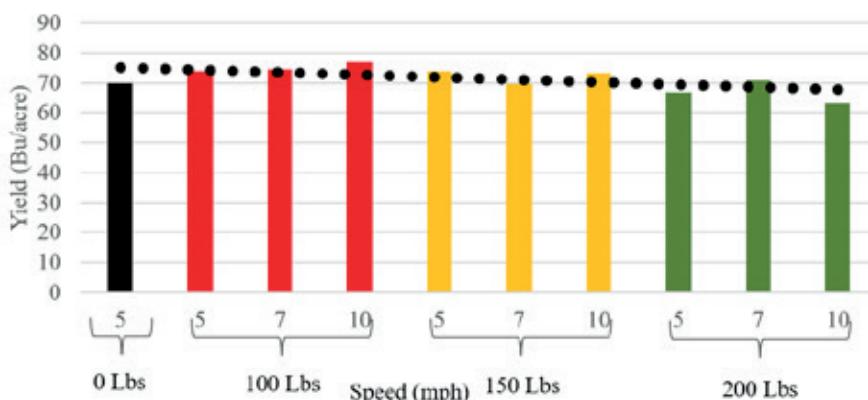


Figure 2. Soybean Emergence Velocity Index on different Speeds and Downforces

THE IMPORTANCE OF MAINTAINING HIGH UNIFORMITY OF WATER APPLICATION OF CENTER PIVOT

CONTRIBUTING ORGANIZATION | Nebraska Soybean Board - \$18,192

PRIMARY EXTENSION EDUCATORS | Bruno Patias Lena, Mailson Freire de Oliveira, Luan Pereira de Oliveira, Travis J Prochaska (University of Nebraska-Lincoln)

This research focuses on evaluating the Uniformity of Water Application (UWA) in three center pivots in Nebraska. The objectives were to assess UWA before and after replacing nozzle packages to understand the impact of low UWA on crop yield. A catch-can test method was used to determine UWA by placing cups underneath the pivots to measure irrigation depth. One catch can test was conducted before, and another after the nozzles were replaced. This allowed not only checking for improvement in uniformity after nozzle replacement but also relating that to potential yield losses.

A well-maintained center pivot is designed to operate with a UWA of over 90%. However, factors such as natural wear and tear of the sprinkler package and the installation or replacement of nozzles with improper sizes can reduce UWA, ultimately reducing yield. The negative impact of low UWA is generally larger during dry growing seasons when the total irrigation water requirement increases. This was the norm in 2022 and 2023 at several locations in Nebraska.

Before nozzle replacement, UWA values were 78%, 59%, and 23%. Post-replacement, UWA significantly improved to 92%, 90%, and 74%, respectively, demonstrating a clear link between maintenance practices and UWA levels. There was a substantial increase in yield uniformity from 2022 (irrigated with the old nozzle package) to 2023 (irrigated with the new nozzle package) (Figure 1).

We conducted an economic analysis using yield data and found some interesting findings. Before conducting this analysis, we asked the grower what the expected yield average values for all his operation was. He mentioned that the yield average for all his operation would be at least 65 bu/ac for soybeans and 230 bu/ac for

corn. In 2022, a substantial portion of the area yielded below the grower’s specified threshold (see Figure 2). This discrepancy from the farmer’s anticipated yield values resulted in a significant potential yield loss for both soybeans and corn – \$9,000 and \$14,500, respectively — totaling about \$23,500. Examining the 2023 yield map (Figure 1), the positive impact of yield stabilization is evident following the

installation of the new nozzle package. Most of the area yielded at or above the 65/230 bu/ac threshold with little impact on profit.

Proactive measures, including simplified catch-can tests and regular checks of yield map data, are recommended for growers to assess UWA and identify potential issues. Replacing the nozzles can reduce potential yield losses by increasing UWA.

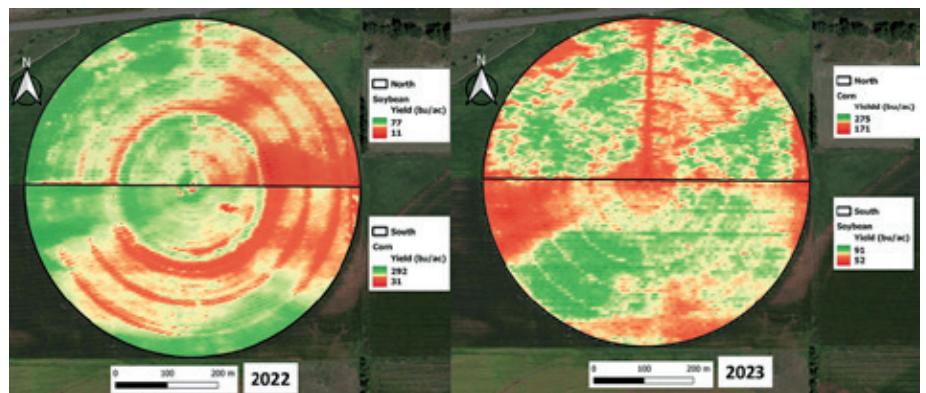


Figure 1. Yield map in 2022 when pivot had old nozzles, and in 2023 with the new nozzles.

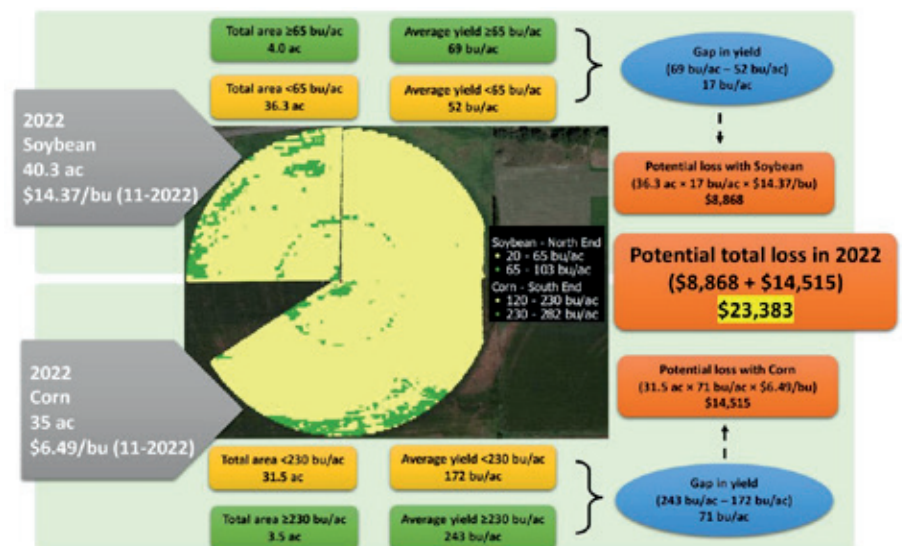


Figure 2. Yield map during 2022 growing season for soybean (north end) and corn (south end). Yellow represents the area under 65 bu/ac for soybean and under 230 bu/ac for corn. Green represents the area over 65 bu/ac for soybean and over 230 bu/ac for corn.

NEBRASKA ON-FARM RESEARCH NETWORK

Providing Reliable, Research-Based Information for Your Farming Decisions

CONTRIBUTING ORGANIZATION | Nebraska Soybean Board - \$48,200

PRIMARY EXTENSION EDUCATOR | Laura Thompson (University of Nebraska-Lincoln)

In a world that is always innovating, farmers are constantly being introduced to new products and practices for use on their operations. Farmers can take the opportunity to learn about these techniques and determine the best practices for their operation by partnering with the Nebraska On-Farm Research Network.

The Nebraska On-Farm Research Network (NOFRN) is a program of Nebraska Extension that partners with farmers to evaluate agricultural products and practices. Farmers participating in on-farm research trials study topics that they choose using their own fields and equipment. Every field is unique, so study protocols are developed to fit the needs of every operation. By partnering with the NOFRN, farmers accelerate their learning about topics impacting farm productivity, profitability and sustainability.

During the 2023 growing season, Nebraska farmers conducted 97 studies with the NOFRN, addressing topics such as crop production, fertility and soil management, nontraditional biological products and additives, cover crops, crop protection and equipment.

Nebraska soybean farmers have spent the past several years partnering with the NOFRN to discover the most efficient soybean seeding rate for their operations. Many growers typically plant soybeans at 180,000 to 200,000 seeds/ac, but NOFRN studies have consistently shown that

soybean seeding rates of 100,000 to 140,000 seeds/ac result in the greatest economic returns. For a typical farmer, reducing their seeding rate to align with economically optimal seeding rates demonstrated through NOFRN represents a savings of \$19,500 annually (assuming the grower reduces seeding rate from 190,000 seeds/ac to 120,000 seeds/ac, farms 600 acres of soybeans, and a unit of seed costs \$65). In addition, growers are using their precision ag technologies to evaluate the optimum seeding rate for different zones within a field.

Producers have also been evaluating soybean planting date, soybean varieties, nitrogen applications on soybeans, seed treatments, other soybean crop protection, cover crop impacts on soybeans, and more. Results like these are helping farmers make wise decisions for their operations that improve productivity, profitability, and sustainability.

Each year, the Nebraska On-Farm Research Network hosts a series of results update meetings. At these meetings, farmers and agronomists gather to learn about on-farm research conducted during the previous growing season while building connections with other producers throughout the state. The meetings serve as a welcoming environment for on-farm research participants to share about their experiences and for other producers to learn about the on-farm research process. In 2023, attendees at the annual meetings represented over 1.3 million acres and

noted a value of over \$10 million from the information provided! 92% noted they learned new information about crop production practices, 90% learned new information about ag technologies, and 97% were considering making management changes based on the information they received.



Laura Thompson take stand counts for a soybean planting date and rate on farm research study in Richardson County.



If you are interested in participating in the NOFRN, contact Laura Thompson, Extension Educator at 402-245-2224 or laura.thompson@unl.edu, Taylor Lexow, On-Farm Research Program Coordinator at 402-245-2222 or tlexow2@unl.edu or get in touch with your local Nebraska Extension Educator. To learn more about the Nebraska On-Farm Research Network and access results, visit on-farm-research.unl.edu/.



Reliable, research based information for your farm gets presented each year at the On-Farm Research Network's Annual Results Update Meetings.

Things to Know about the NOFRN:

- ▶ Extension personnel provide technical assistance with project set-up, data collection and analysis, so you can have confidence in your results.
- ▶ Scientifically sound experimental designs are used to account for natural and manmade field variables and are customized for individual farmer needs.
- ▶ Statistical analysis is conducted to determine the significance of the results.
- ▶ Ag technologies such as prescriptions, as-applied data and yield monitor data make conducting on-farm research convenient and provide even more powerful insights for growers.
- ▶ Results are shared in person at statewide meetings and online.

2022 Nebraska On-Farm Research Results

Apply previous findings to this year's growing with the **2022 Nebraska On-Farm Research Results book**. Read up on:

- ▶ Soybean population studies (pages 18-22)
- ▶ Soybean population, date and variety (pages 23-25)
- ▶ Variable rate seeding for soybeans (pages 26-29)
- ▶ Soybean maturity groups (pages 30-31)
- ▶ Starter fertilizer on soybeans (pages 36-38)
- ▶ Nitrogen on soybeans (pages 39)
- ▶ Perennial cover crop in soybeans (pages 163)
- ▶ Seed treatments for sudden death syndrome (pages 177)

The 2022 Nebraska On-Farm Research Results book, videos about the projects and over 1000 reports from past on-farm research studies are available at **on-farm-research.unl.edu**.



A CULTURE OF COLLABORATION



NEBRASKA NCSRP DIRECTOR
Mike Tomes - Utica, NE

The North Central Soybean Research Program (NCSRP) is recognized as a leader in multi-state collaborative research and outreach efforts to support soybean farmers and drive the soybean industry forward.

The focus of NCSRP is soybean production research and extension outreach. We invest soybean checkoff funds in university research and extension programs to better understand and manage plant stressors that reduce soybean yield and farmer

profitability. NCSRP's emphasis on enhancing and protecting soybean yield through genetics and agronomic practices contributes to soybean farmer success today and tomorrow.

Farmer leaders, state staff and funded researchers work together to prioritize, monitor and communicate the basic and applied science efforts on behalf of more than 350,000 soybean farmers in the region, representing more than 85% of the nation's soybean production.

Projects Funded for FY2023

- ▶ An integrated approach to enhance durability of SCN resistance for long-term, strategic SCN management (Phase III)
- ▶ Using data-driven knowledge for profitable soybean management systems
- ▶ Field phenotyping using machine learning tools integrated with genetic mapping to address heat- and drought-induced flower abortion in soybean
- ▶ Improving flood and drought tolerance for soybeans in North Central region

Nebraska Soybean Board Investment in FY23 - \$550,000

- ▶ SOYGEN3: Building capacity to increase soybean genetic gain in future environments for seed yield and composition through combining genomics-assisted breeding with environmental characterization
- ▶ Mapping soybean protein and oil quality in farmer fields
- ▶ Multi-dimensional approaches for improved productivity, sustainability and management of major soybean diseases in the North Central U.S.
- ▶ The SCN Coalition: Economics and Advancing Management
- ▶ Site-specific weed management with precision application technology
- ▶ Research and extension on emerging soybean pests in the North Central region
- ▶ SoyRenSeq: a novel approach for disease resistance gene discovery and application for soybean improvement

FY2023 NSB RESEARCH FUNDING AREAS

Funding critical research and exploring topics that matter to Nebraska farmers is a top priority for the Nebraska Soybean Board.

