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RESEARCH ISSUE 2026

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2026 Dry Bean Research Reports


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RESEARCH 2026

Greetings,

I hope this issue finds our fellow growers well and enjoying being back in the fields after a long winter.

Every year Notharvest Bean Growers Association, along with the North Dakota Dry Bean Council and the Minnesota Dry Bean Research & Promotion Council, helps fund dry bean research to support growers and strengthen our industry. Dry beans are a specialty crop, and they can be challenging. With little private-sector research in our industry, it is important that we continue to support practical, grower-focused projects.

Funding this work matters. It matters to our Industry, to our fellow growers, to our bottom line, and the future of dry bean production in Minnesota and North Dakota. This annual research issue is intended to highlight that work, and the substantial investment growers are making on behalf of our fellow producers. We hope this issue will be useful as you make decisions for your operation.

On behalf of NBGA Directors and Council members, thank you for reading.

Wishing you all a safe & productive growing season,

- Karl Jodock
Chair, NBGA Research Committee
Northwood, ND. (District 3)

NORTHARVEST
BEANGROWER

PUBLISHED BY

urban toad MEDIA

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urbantoadmedia.com

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DRY BEAN IMPROVEMENT FOR THE U.S. NORTHERN PLAINS

A Grant Proposal for Northarvest Bean Growers Association - February 2026

Juan M. Osorno Ph.D.

2025 Milestones:

Dry bean variety usage is not tracked by USDA-NASS in North Dakota, so for now, we have to rely on Foundation seed sales to indirectly assess the impact of NDSU dry bean varieties:

Just in 2024, more than 281,000 lbs of Foundation seed was sold to the industry across 9 different market classes such as pinto, slow darkening pinto, black, navy, among others:

Assuming a conservative seed conversion rate of 1:20 for both registered and certified seed classes and across all market classes, each year there should be ~112 million lbs of certified seed of NDSU varieties available. Assuming an average price for certified seed of $1 USD per lb, this would represent ~$112 million USD just in seed sales, or a return on investment (ROI) of ~$139 USD per every dollar invested in the NDSU dry bean breeding program.

In terms of area, there should be enough certified seed of NDSU dry bean varieties in the system to plant ~112,000

"The NDSU Dry Bean Breeding program [largest in the U.S.] represents the most seamless bridge between research and real-world impact on the bean value chain." – Juan M. Osorno Ph.D.

NDSU is also modernizing its pipeline by deploying unmanned aerial vehicles for high-throughput phenotyping and a 4,000-marker DNA screening chip to increase selection efficiency.

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Graduate Students: Maria de Oliveira (Ph.D.), and Carly George (M.S.)

acres or 17% of the total area planted with dry beans (~650,000 acres in total).

Currently, approximately 17 dry bean varieties developed by NDSU are available to our growers and industry. NDSU Foundation seedstocks reported that for 2025, seed of most of these varieties was classified as "sold out". This is a good indication of the interest that the bean industry has in utilizing the varieties released by the NDSU dry bean breeding program and its economic impact in the region. Contrastingly, seed requests for 2026 (as of February 10) have been significantly less compared with previous years, signaling the current uncertainty of the markets.

- A new black bean variety was released in early 2025 by NDSU: **ND Galaxy is a high yielding black bean variety** with upright plant architecture, resistance to Bean Common Mosaic Virus and Bean Common Mosaic Necrosis Viru, intermediate resistance to common bacterial blight, and excellent seed shape, size, color, and canning quality.

- Early in 2026, 2 additional new varieties were released: **ND Redvelvet** small red and **ND Pink-Slipper** light red kidney.

- Recent research results are showing that in addition to the visual seed quality aspects of slow darkening pintos, this newer sub-market class also offer **faster cooking time as well as higher iron bioavailability**. This is a great case for added value on a product already being grown in ~35-40% of the pinto acreage in North Dakota.

- **Collaborative research continues to identify new sources of resistance to Soybean Cyst Nematodes** in dry beans across different SCN types/populations in order to obtain durable and broad resistance. In addition, we continue looking for **varieties tolerant to waterlogging conditions and high soil salinity**.

- In order to increase efficiency, the **NDSU dry bean breeding program is using Unmanned Aerial Vehicles (UAV)** to attempt to measure some of the agronomic traits normally measured in the field manually. This is known in plant breeding as High Throughput Phenotyping (HTP) and allows to record and measure hundreds or thousands of genotypes in a short period of time and with high accuracy.

- **A new DNA screening chip has been developed for the dry bean breeding program that will allow us to get the genomic profile from each line in the program** for ~4,000 DNA markers associated with traits of economic interest. This will allow us to discard some lines that don't need to be tested in the field, which should save time and resources.

- Additional research is being focused on the following topics: disease resistance (white mold, rust, common bacterial blight, root rots, anthracnose, among others), plant architecture, bruchid/weevil resistance, biological nitrogen fixation, seed quality, and seed yield gain.

In order to save space in this proposal, additional details about 2025 activities and milestones can be found in the annual report (available upon request). For specific requests and questions, you can contact Juan Osorno directly.

I – Long-Term Breeding Objectives

The objective of the dry bean breeding program at NDSU is to **develop high yielding, high quality dry bean cultivars adapted to the northern Great Plains using genetics and breeding modern tools**. This involves many characteristics of dry beans and different disciplines of research (e.g., genetics/breeding, pathology, physiology, soils, nutrition, etc.). The main priority is to improve pinto, navy, black, and kidney market classes, but also great northern, red, and pink. Crosses involve adapted cultivars grown in the Northern Plains, breeding lines developed at NDSU, and germplasm possessing desirable traits from other breeding programs and regions. Each year, the breeding program evaluates material from around the world as possible sources of resistance/tolerance to both biotic and abiotic stresses. **New crosses and parental combinations are made each year so there is a continuous feeding of new genetic material through the breeding pipeline. As new material enters into the breeding program, testing and selection (both phenotypic and genotypic) allows to keep the superior material while eliminating lines with undesirable traits/characteristics**. All this process involves a combination of multiple disciplines besides breeding/genetics such as genomics/bioinformatics, production agronomy, pathology, plant physiology, and food science, among others.

II- Target Traits:

The MIN-DAK region is the largest dry bean producing region but is also a very unique environment. Therefore, we focus our effort in developing improved varieties that are well adapted to these growing conditions. **Breeding efforts are focused on: high seed yield and overall productivity, upright plant architecture, early or acceptable maturity and drydown, seed visual (size, shape, color, canning/ cooking) and nutritional quality, resistance/tolerance to abiotic stress (waterlogging and intermittent drought), resistance/tolerance to diseases such as white mold, rust, root rots, anthracnose, bean common mosaic virus, bacterial blights, and soybean cyst nematode, among others. Many of these target traits are part of the NBGA list of "areas of interest", making the NDSU breeding program highly relevant and impactful for the region**.

Many of these breeding activities can only be accomplished by having an **already organized multi-disciplinary team at NDSU that includes other scientists such as agronomy/ extension personnel, genomists, plant pathologists, physiologists, soil scientists, in addition to external public and private partners**. The NBGA list of "areas of interest" **highlights the critical importance of organized multi-disciplinary research efforts. Since a good variety is a combination of multiple desirable traits, the NDSU dry bean breeding program has the ability to combine the knowledge and results from all these basic/applied research efforts into a commercial product with added value: a new improved variety**.

Breeding activities vary throughout the year but in general, it follows a similar cycle across years: cross, test/ evaluate across multiple locations, and select the best lines for the next breeding cycle. A modified pedigree breeding method is used, which allows continual evaluation and selection of desirable breeding families and/or lines. Therefore, activities and procedures remain relatively similar from year to year, providing consistency in development and evaluation of new genetic materials in a step-wise manner. This is often known as the "breeding pipeline", which is nothing more than a dynamic flow of breeding lines developed through the process of crossing, evaluating, and selecting across several cycles. **Total time from initial cross to variety release takes at least 7-8 years**. For more details, here is a video about the breeding process at the NDSU dry bean breeding program: https:// youtu.be/IkOxJDycRi4.

During the winter of each year, we perform approximately 250 unique hybridizations or crosses in the greenhouse. Crosses involve adapted cultivars grown in the northern Great Plains, breeding lines developed at NDSU, and germplasm possessing desirable traits from other breeding programs and regions. Unadapted germplasm lines from other regions are evaluated for desirable traits and crossed with adapted material. **Each year, the breeding program evaluates material from around the world as possible sources of stress tolerance (flooding, salinity, etc.), disease resistance to white mold, rust, root rot, anthracnose, viruses, soybean cyst nematode, and bacterial blights, among others**. In some cases, inoculum for disease screening and additional evaluation is provided by the Plant Pathology Dept. In addition, successful collaboration with scientists in other departments at NDSU and scientists from other institutions, universities, and private companies in the U.S. and the world, offer unique opportunities to expand the knowledge base of bean genetics and have a direct impact on dry bean production.

Financial support and long-term commitment from Northarvest Bean Growers Association has been crucial for the ongoing success of this project.

The Dry Bean Variety Trials grown at more than 8 locations in North Dakota and two in Minnesota includes all the public and private varieties plus few breeding lines at final stages of testing. This is a great decision tool not only for growers but for public and private breeding programs when deciding about a new variety release. The NDSU dry bean breeding program continues to test and screen every year thousands of early generation genotypes, hundreds of preliminary and advanced breeding lines, commercial cultivars, and other germplasm. **On average, every year the NDSU dry bean breeding program grows field trials and nurseries accounting for ~8,000 plots across all 8 locations that when combined are equivalent to ~35 acres. Consequently, this is the largest public dry bean breeding program in the USA. In addition, variety testing is made in collaboration with the NDSU Research and Extension Centers (REC) across the state**. Results of these variety trials can be found in the NDSU-Extension publication A-654. In addition, the aid of winter nurseries that were made at Puerto Rico (~2000 early-generation rows each year plus breeder seed increases), and New Zealand (~250 F1 rows plus breeder seed increases), help to speed up the breeding process, especially at the early generations. ▪


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USDA
Rattler
PVP 202000255
Pinto

2025 Dry Bean Variety Trial Results Highlight Performance and Stability Across North Dakota

Dry bean production continues to play a significant role in North Dakota's agricultural economy, with diverse market classes including Pinto, Great Northern, Black, Navy, Pink, Small Red, and Adzuki beans. The 2025 NDSU dry bean variety trials, conducted across multiple Research Extension Center (REC) locations, provided valuable insight into varietal performance under one of the more environmentally variable seasons in recent years. As always, yield performance is only one factor in variety selection, and growers are encouraged to confirm acceptance and marketability with their processor or canner before making planting decisions.

The 2025 growing season was defined by variability. Periods of excess moisture, localized storms, hail, and wind affected stand establishment and crop performance in several regions. Elevated moisture during flowering and pod fill increased white mold and bacterial disease pressure at some sites. In addition, late-season rainfall and early frost events in portions of the state delayed harvest and reduced seed quality. While some locations experienced yields below long-term averages, others benefited from timely precipitation and avoided severe disease pressure, creating wide differences among sites and fields.

Dry bean variety trials were conducted at Oakes (irrigated/conventional tillage), Carrington (irrigated/conventional tillage and dryland/conventional tillage), Wishek (Tri County site/no tillage), Langdon (dryland/conventional tillage), Hettinger (dryland/no tillage), and Nesson Valley (irrigated/conventional tillage). The Minot trial (dryland/no tillage) was unfortunately lost to high weed pressure. Collectively, these sites captured much of the environmental diversity North Dakota producers experienced during the 2025 season and provided a meaningful comparison of varietal response under differing moisture and disease conditions.

One of the more notable findings this year occurred at Carrington, where the margin between irrigated and dryland yields was unexpectedly narrow. Due to above-average precipitation, supplemental irrigation offered little advantage in many cases. In the medium seed classes, Pinto, Pink, and Great Northern, the top irrigated entry, USDA Rattler, yielded 2,146 lb/a, while the top dryland entry, Eiger, slightly exceeded that at 2,203 lb/a. Dryland yields generally ranged between 2,000 and 2,200 lb/a, closely matching irrigated performance. A similar trend was observed in the small seed classes. Irrigated plots peaked at 2,370 lb/a with ND Twilight, while dryland plots reached 2,322 lb/a with Slate. These results suggest that in high-precipitation years, careful irrigation management is critical, as excessive moisture may contribute to increased disease pressure without improving yield.

Adzuki beans were included in the Carrington public dryland trial in 2025. Although yields were lower than traditional dry bean classes, ranging from approximately 900 to 1,150 lb/a, the initial data indicate potential for this specialty crop. With an appeal to niche and value-added markets, Adzuki beans may offer diversification opportunities for growers. Additional years of evaluation

> Weather variability, disease pressure, irrigation response, and market considerations all influence the performance and profitability of dry bean varieties.

will be necessary to better define yield expectations and management strategies.

Across the state, the highest site yields in 2025 were recorded at Langdon under dryland conditions and at Oakes under irrigation. However, single-year performance can be heavily influenced by localized weather patterns. For that reason, multi-year data remain the most reliable tool for reducing risk in variety selection. Several varieties have demonstrated strong stability across years and environments. ND Pegasus, a Great Northern variety, has consistently ranked among the top performers statewide in both two- and three-year averages. USDA Rattler has maintained strong performance in both northern and central regions, while ND Galaxy and ND Twilight continue to serve as dependable standards in the black bean market class. These varieties have shown the ability to maintain competitive yields despite fluctuating environmental pressures.

The Tri County trial near Wishek was again conducted in 2025 and continues to provide valuable localized data for producers in the south-central region. In addition to pinto, black, and navy beans, entries such as ND Pegasus (Great Northern), ND Rosalind (Pink), and Viper (Small Red) were included to broaden comparisons across market classes and support diversified production decisions.

As growers evaluate results from the 2025 season, several considerations remain important. Multi-year, region-specific data should guide decisions more heavily than a single season's results, particularly in years marked by environmental extremes. Irrigation management should be adapted to seasonal conditions to avoid compounding disease risk during wet years. Most importantly, yield performance should be considered alongside contract availability, processor acceptance, and market demand. Variety trial data are intended to support informed decisions, but final selections should align with marketing opportunities and quality requirements.

Kristin Simons

For growers operating under organic management, varieties such as Cowboy and ND Galaxy demonstrated competitive performance comparable to conventional systems in 2025. These results suggest that certain genetics may transition well into organic production, offering good adaptability and competitive ability.

The 2025 season reinforced the value of multi-location testing across North Dakota. Weather variability, disease pressure, irrigation response, and market considerations all influence the performance and profitability of dry bean varieties. Continued statewide testing ensures producers have access to unbiased, regionally relevant data to support informed and economically sound variety decisions. ▪

North Dakota Dry Edible Bean Variety Trials
Progress Report (2025 Growing Season)

During the 2025 growing season, the statewide dry bean variety trial was successfully conducted across irrigated and dryland environments, generating a robust dataset that builds directly on prior years of evaluation and supports continuation of the project.

Trials were established at multiple NDSU Research Extension Center locations, including irrigated sites at Oakes (Dickey County) and Carrington, and dryland sites at Carrington, Langdon, Hettinger, Wishek, and Williston (Nesson Valley). This multi-environment approach captured a wide range of growing conditions and production challenges, strengthening the relevance of results for North Dakota producers.

Weather-related stress events occurred at several locations, including:

White mold pressure and multiple low-temperature events (34–35°F) in early September at Carrington (irrigated and dryland), which reduced yield potential in later-maturing entries.

A frost event at Wishek prior to full maturity of all lines, affecting some yield and quality measurements.
The Carrington dryland site was re-established successfully in 2025 following complete hail loss in 2024, allowing restoration of 2- and 3-year averages for several entries.

Despite these challenges, trials were harvested successfully and provided usable, statistically analyzed data, demonstrating effective management and appropriate site selection.

Data Collection

Agronomic and yield-related data were collected following established protocols to ensure consistency across locations. Measurements included:

- Days to maturity
- Plant height at maturity
- Lodging and harvestability ratings
- Direct harvest ratings where applicable
- One hundred seed weight
- Test weight
- Seed yield

Additional observations, including disease incidence and environmental stress, were recorded throughout the growing season. Data were analyzed using analysis of variance with the least significant difference (LSD) values calculated at the 10% level.

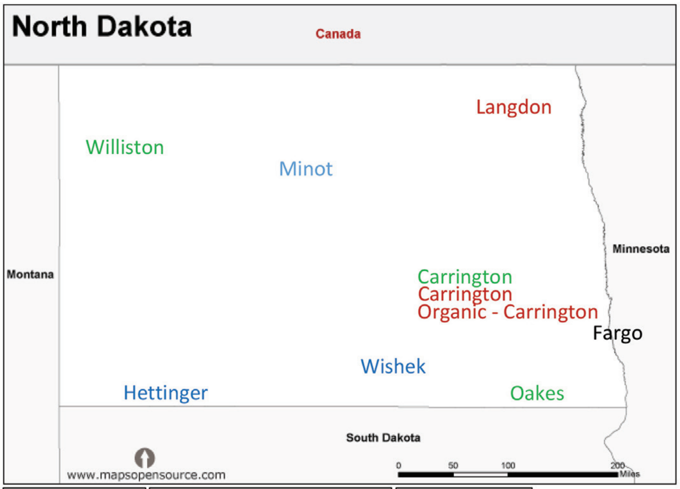
Summary of Results

Yield performance varied considerably among locations in 2025, reflecting the diverse environmental conditions encountered across the state. The highest overall yields were observed at irrigated Oakes and dryland Langdon, while other sites experienced yield reductions due to excess moisture, disease pressure, or early frost. Weeds significantly affected the trial results at Minot and thus the Minot trial was not published.

Several varieties demonstrated strong yield stability across locations and years:
ND Pegasus (Great Northern) consistently ranked among the top-performing varieties statewide and maintained strong two- and three-year yield averages.

USDA Rattler (Pinto) performed well across northern and central regions under both irrigated and dryland conditions.

ND Galaxy and ND Twilight (Black) continued to show reliable performance across multiple environments.



No till	Irrigated Conventional	Dryland

PI: Kristin Simons, Research Agronomist
Co-PI's: Lawrence Henry – Langdon REC, Mike Ostlie – Oakes, John Rickertsen – Hettinger REC, Tyler Tjelde – Williston REC, Leandro Bortolon – North Central REC (Minot), Qasim Khan – Organic Carrington REC

Key 2025 Outcomes by Environment

Irrigated – Oakes (Dickey County):

- Trial mean yield exceeded 3,400 lb/a, for miscellaneous classes and 3,070 lb/a, for pinto beans.
- ND Rosalind (pink) and Eiger (Great Northern) were among the highest-yielding entries.
- Among pintos, ND Rodeo and a couple of experimental lines with white mold tolerance were top yielders.

Irrigated – Carrington:

- Average yields ranged from ~2,300 lb/a (misc.) to ~1,800 lb/a (pinto/SD-pinto) under disease and cold stress.
- HMS Medalist (navy), ND Galaxy (black), and ND Pegasus (Great Northern) performed consistently relative to multi-year averages.
- Data contributed to updated 3-year performance summaries, strengthening long-term comparisons.

Dryland – Carrington:

- Yield was impacted by white mold and early-season cold, but varietal differences remained evident.
- ND Twilight, T9905, and ND Pegasus showed strong relative performance across multiple years.
- Restoration of 2- and 3-year averages (2023–2025) improved dataset continuity after the 2024 hail loss.

Organic – Carrington:

Cowboy and ND Galaxy demonstrated competitive performance comparable to the conventional system suggesting that certain genetics may transition well into organic production.

Wishek (Dryland):

- Trial mean yield exceeded 3,300 lb/a, despite a frost event.
- ND Pegasus, USDA Rattler, ND Rodeo, and T9905 were among the top yielders.
- Protein and test weight data added value for market-oriented variety selection.

Langdon, Hettinger, and Nesson Valley:

- These sites provided critical long-term yield stability data, with Langdon including four-year yield histories (2022–2025) for released varieties.
- ND Pegasus, Vibrant, HMS Medalist, and Windbreaker demonstrated consistent multi-year performance.

Outputs and Dissemination

All site-level results have been prepared for annual publication and public access, including:

- Posting to the NDSU Variety Trials website (https://vt.ag.ndsu.edu/)
- Inclusion in Extension publications and REC annual reports (NDSU Extension Bulletin A654,
- "North Dakota Dry Bean Variety Trial Results and Selection Guide")
- Use in grower meetings and association communications ▪

EVALUATING DRY BEANS AS A SOURCE OF HIGH QUALITY VALUE PROTEIN INGREDIENTS

Progress Report

Continuing project objectives from last year: 1) Develop optimized protein extraction processes for the production of functional bean protein isolates; 2) Evaluate the navy protein isolates, produced following pH and salt extraction from two navy bean varieties grown in two locations, for structural, functional, and nutritional properties in comparison to commercial ingredients; 3) Evaluate the scalability of the developed protein extraction process; and 4) Optimize dry fractionation of navy bean by air classification and compare product characteristics to those of the protein isolate.

For **Objective 1**, navy beans were sourced through the help of Northarvest Bean Growers Association and sent to AURI for dehulling and milling. As shown in last year's report, production of navy bean protein isolate (NBPI) was optimized following two extraction methods, pH-extraction and salt extraction. Based on **Objective 2** results, protein isolates from two bean varieties grown in two locations showed that NBPI produced via pH extraction had better overall solubility and gelation properties, so we moved ahead with adopting pH extraction as the chosen method for producing and scaling NBPI. In addition, production of NBPI following pH extraction under mild conditions was adopted due to the efficiency and better scalability of the method compared to salt extraction. The evaluation of the nutritional properties of the isolates is underway. Production of the protein isolates in the pilot plant for **Objective 3** was delayed due to issues with the decanter needed for the isolation process. In the meantime, excellent progress toward **Objective 4** was made. Dry fractionation by air classification was optimized in collaboration with HOSOKAWA MICRON POWDER SYSTEMS in New Jersey to obtain navy bean protein concentrate (NBPC) with increased protein purity and acceptable yield. The NBPC produced had relatively high protein extraction yield and acceptable purity (**Table 1**), double that of the original flour. A key characteristic of air classification is the trade-off between protein yield and purity. Generally, air classification is limited to the production of protein concentrates rather than isolates, with reported protein contents for pulses ranging between 40 and 55%, depending on the protein content of the starting material and on the processing conditions.

"Results thus far proved that dry beans have a strong potential as a source of functional protein ingredients that can favorably compete with commercial protein ingredients. This outcome will definitely increase the value of dry beans and result in added revenue to bean farmers in Minnesota and the Northwest region."– Dr. Pam Ismail, Plant Protein Innovation Center

Table 1. Percent protein purity and yield distribution from pH-extracted navy bean protein isolate, pellet, supernatant and from air classified protein-rich fine fraction, starch-rich coarse fraction, and residual dust.

	Protein Purity (%)	Protein Yield [a] (%)
	pH extraction	
NBPI (Protein)	**77.7**	**55.6**
Pellet [b]	6.7	18.1
Residual Supernatant [c]	27.7	24.3
	Air classification	
NBPC (Fine Fraction)	**41.4**	**70.5**
Coarse Fraction	13.2	27.6
Residual Dust [d]	20.2	0.8

[a] Protein yield (%) represents the amount of protein extracted relative to the total amount of protein in the starting navy bean flour; [b] Pellet discarded after alkaline solubilization; [c] Supernatant discarded after isoelectric precipitation; [d] Residual dust discarded after air classification processing.

The structural (***Figure 1***, ***Table 2***) and functional properties of NBPC was evaluated and compared to NBPI, produced following the optimized pH extraction, and to two commercial protein ingredients, soy protein isolate (cSPI, 90.4% protein) and pea protein isolate (cPPI, 73.8% protein). The protein components in NBPC were similar to those in NBPI and were less polymerized compared to the commercial samples (**Figure 1**). While NBPC had similar denaturation pattern to NBPI, it had lower surface hydrophobicity and less net charge than, particularly at pH 3.4 (**Table 2**). Such low surface charge of NBPC at acidic pH contributed to lower solubility under acidic conditions (**Table 3**).

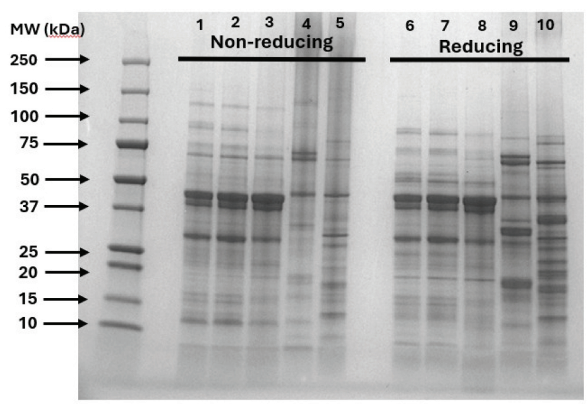


Figure 1. SDS-PAGE gel protein profile of NBPC and NBPI under non-reducing and reducing conditions. Lane (1,6): NBPC Coarse Fraction; Lane (2,7): NBPC Fine Fraction; Lane (3,8): NBPI; Lane (4,9): cSPI; Lane (5,10): cPPI.

Table 2. Denaturation temperatures and enthalpy, surface hydrophobicity and surface charge of NBPC, NBPI, cPPI and cSPI.

Samples	Denaturation temperature (◦C)		Enthalpy of Denaturation (J/g)		Surface Hydrophobicity RFI	Surface charge (mV)	
	Peak 1	Peak 2	Peak 1	Peak 2		pH 7	pH 3.4
NBPI	80.7	98.6	0.43	11.25	4096.2	-39.5	26.3
NBPC	81.0	96.2	1.90	7.58	2828.6	-33.5	3.4
cPPI	-	-	-	-	9604.9	-33.5	22.1
cSPI	-	-	-	-	7709.5	-42.6	30.9

Table 3. Solubility, gel strength, and emulsification capacity of NBPC, NBPI, cPPI and cSPI.

Sample	Protein solubility (%)				Emulsification Capacity (g oil/g protein)	Gel Strength (N)	
	pH 7		pH 3.4				
	Non-Heated	Heated at 80°C	Non-Heated	Heated at 80°C		12.5 %	15%
NBPI	93.7	90.6	80.8	78.6	723.7	12.0	19.1
NBPC	98.7	83.3	36.8	32.9	1208.3	27.0	34.7
cPPI	21.5	34.3	9.1	15.1	374.1	N/A	11.7
cSPI	69.1	83.7	39.1	48.3	926.1	N/A	21.3

N/A indicates that measurements were not taken under specified conditions

Nevertheless, **NBPC *demonstrated favorable techno-functional properties, often superior or comparable to its isolate counterpart and to cPPI and cSPI.*** Uniquely, **NBPC *had superior gelation properties*** and emulsification properties, which could make this concentrate an excellent candidate as egg or meat replacer. ***This is the first study*** to compare wet vs. dry protein extractionfrom navy beans in terms of protein structure and functionality. ***These findings highlight that navy bean protein concentrate can serve as a high-performance, clean-label alternative to energy-intensive protein isolates.***

While working on developing and characterizing navy bean protein ingredients, *we partnered with Buhler to dehull kidney and pinto beans.* Overcoming the dehulling of these beans is the first step needed prior to development of protein ingredients. Bühler team was able to successfully dehull kidney and pinto beans provided by Northarvest Bean Grower Association. Kidney beans showed a dehulling efficiency of 94.9% and a yield of 82.8% (**Figure 2**). In contrast, pinto beans were more resistant to seed coat removal and required a second pass through the pulse dehuller to achieve a comparable dehulling efficiency of 93.0% and yield of 82.7% (**Figure 3**). Following dehulling, the beans were prepared for protein extraction and subsequent analysis to evaluate their potential as functional and nutritious protein ingredients, achieving an **85–95% dehulling efficiency** with an **80–83% yield**. The goal was to maximize the dehulling degree while maintaining high yield, as well as to reduce anti-nutrient content through removal of the seed coat. These dehulled beans are now ready to be used for the production of functional and nutritional protein concentrates and isolates, building on the learning we acquired so far working from working with navy beans. These protein ingredients will be suitable for the incorporation into various high protein food products.

Figure 2. Kidney beans following pulse dehulling.

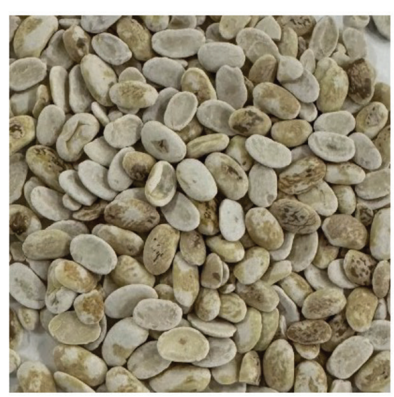


Figure 3. Pinto beans following pulse dehulling.

In summary results thus far proved that dry beans have a strong potential as a source of functional protein ingredients that can favorably compete with commercial protein ingredients. This outcome will definitely increase the value of dry beans and result in added revenue to bean farmers in Minnesota and the Northwest region. ▪

2025 Dry Edible Bean Disease Research Report

Dry bean production in the Northarvest region is significantly impacted by a range of diseases and pests. Above-ground plant parts are commonly infected by fungi such as Uromyces appendiculatus, the cause of bean rust; Colletotrichum lindemuthianum, responsible for anthracnose; and Sclerotinia sclerotiorum, the pathogen behind white mold. Bacterial pathogens, including Xanthomonas campestris pv. phaseoli, which causes common bacterial blight (CBB), Pseudomonas syringae pv. phaseolicola, responsible for halo blight (HB), and Pseudomonas syringae pv. syringae, which causes brown spot (BS), also contribute to significant crop losses. Additionally, root-infecting pathogens, such as Rhizoctonia solani, Fusarium spp., and Pythium spp., are known to cause root rot. These soilborne pathogens can be especially damaging, with severe infections potentially leading to plant death.

Monitor dry bean diseases in the Northarvest region: Dry bean survey 2025

In 2025, we conducted surveys on 20 dry bean fields across four counties in North Dakota (Grand Forks, Pembina, Traill, and Walsh) and 10 fields in three Minnesota counties (Becker, Hubbard, and Otter Tail) from July 1st to August 27th. In total, we went to 12 fields with Pinto bean, 12 fields with Navy bean, 1 field with Black bean, 4 fields with Kidney bean, and 1 field with Cranberry bean. To assess a wide range of diseases, we performed scouting at three key stages throughout the growing season: July 1–3 for root rots, July 29–31 for bacterial blight (and white mold), and August 19–27 for rust and white mold (Table 1). In short, we walk through the field in a 'W' pattern, a standard field scouting technique used to efficiently sample for diseases. At each of the 5 sampling spots, we visually assess 20 plants. So for a whole field we visually assess 100 plants. As in previous years, root rot was identified in all surveyed fields, however, although it was observed in all fields, the general disease incidence was low to medium, ranging from a field with 5% (5 root rot symptom displaying plants out of 100 plant visually assessed) to a field 38% (38 root rot symptom displaying plants out of 100 plant visually assessed) (Table 2). White mold was present in 28 out of 30 fields in both states, North Dakota and Minnesota with an incidence level between 0% and a high of 89%. Due to the high numbers of fields affected, we decided to collect samples of Sclerotinia from this survey. However, no rust was observed in any of the fields. Additionally, bacterial disease symptoms were found at similar levels as the previous year. In 24 out of 30 fields we observed plants with CBB symptoms, in 9 fields out of 30 fields we observed plants with Brown spot symptoms, and in 2 fields out of 30 fields we observed plants with Halo blight symptoms. By regularly monitoring plant pathogens, we can detect emerging diseases, unusually high disease pressures, and shifts in pathogen populations, such as

"The 2025 dry edible bean disease survey across North Dakota and Minnesota found that root rot, white mold, and bacterial diseases were the most widespread issues in the fields surveyed." – Malaika Ebert, Dry Bean and Pulse Crop Pathologist

Principal Investigators:
Malaika Ebert, dry bean and pulse crop pathologist

potential fungicide resistance. Symptomatic plants are collected during the surveys and brought back to our laboratory for diagnostic testing, where pathogens are identified and evaluated.

Collecting white mold isolates in 2025.

Due to the high occurrence of white mold in fields in North Dakota and Minnesota, we proactively pushed for a big (unplanned) sampling effort. We took samples of diseased plants from the fields to further process them in the laboratory. After multiple rounds of cleaning the isolates, we were able to isolate and clean up 36 Sclerotinia strains that are currently put into long term storage and are available for white mold screenings of new bean varieties.

Take CBB samples from the survey fields to the lab, isolate and test the pathogen for level of aggressiveness in the greenhouse

We decided to take samples of the bacteria-infected leaves back to the lab for further analysis in order to better understand the pathogens affecting the dry bean crops. From the infected field samples, we carefully isolated bacterial strains and plated the purified isolates onto differential selective media. To ensure accurate identification, we used a dual approach for species characterization. In addition to the differential media (Figure 1), we also performed DNA sequencing, which provided a more precise and definitive identification of the bacterial species present in the samples. This allowed us to cross-verify our findings and confirm species allocation.

Through this process, we successfully identified 3 isolates of Pseudomonas syringae pv. phaseolicola, the causal agent of halo blight, 20 isolates of Pseudomonas syringae pv. syringae, which causes brown spot, and 5 isolates of Xanthomonas spp., the bacterium responsible for common bacterial blight by morphology (Figure 1). After DNA 16S sequencing, we were able to confirm 3 isolates of Pseudomonas syringae pv. phaseolicola, 13 isolates of Pseudomonas syringae pv. syringae, and 5 isolates of Xanthomonas spp. Interestingly, the high numbers of CBB symptom observations in the fields were not directly reflected in the isolated Xanthomonas species. The Blastn searches of the sequences of the 5 Xanthomonas isolates indicated that they appear to have highest identity to Xanthomonas arboricola not to the bean-infecting Xanthomonas phaseoli pv. phaseoli. Additionally, when tested in the greenhouse in infection assays, none on the isolates displayed typical CBB symptoms (Figure 2). Xanthomonas arboricola is a Xanthomonas species that can cause disease in trees of the Prunus genus (stonefruits), walnut, and hazelnut (Lamichhane, 2014). To avoid sequencing errors, we also went back to long term storage and sequenced previously isolated Xanthomonas phaseoli pv. phaseoli isolates to compare 16S sequences with (Figure 3A and B) and confirmed that indeed the sequences were not identical. Furthermore, we sequenced the whole genomes of 3 of the 5 Xanthomonas arboricola isolates from this survey and also based on the entirety of genes (not only the 16S region), the Xanthomonas species from the 2025 survey are closest related to Xanthomonas arboricola. Furthermore, we noticed that the symptoms cause by all Xanthomonas arboricola isolates collected from our bean survey on dry bean did not look like classical CBB symptoms. In fact, they look very similar to published symptoms of Xanthomonas arboricola on stone fruit (Han et al., 2021). Therefore, we are fairly confident that all Xanthomonas isolates samples in the 2025 dry bean survey are Xanthomonas arboricola isolates. We currently have no explanation on how/why Xanthomonas arboricola is currently found in dry bean fields in ND and MN, however we will keep an eye on this development.

As all Xanthomonas isolates sampled in the dry bean survey turned out to be Xanthomonas arboricola, we will use one of the previously collected and confirmed Xanthomonas phaseoli pv. phaseoli for investigating the transcriptomics of Xanthomonas phaseoli pv. phaseoli during dry bean infection. Trial RNA extractions of pure bacterial culture were used to adjust protocols to yield a high amount of high quality RNA from pure culture. Therefore, we have moved on to test runs of RNA extraction from plants infected with Xanthomonas phaseoli pv. phaseoli as quantity of bacterial RNA will be extremely little to dry bean RNA.

Whole genome sequencing of Fusarium species isolated during dry bean surveys.

It was proposed to sequence a total of 12 Fusarium species isolated during a dry bean survey in North Dakota or Minnesota. We currently have 3 Fusarium species sequenced and for another 3 Fusarium species, we have the libraries prepared and will run them on our Oxford Nanopore Sequencer as soon as possible. Another 2 Fusarium species are clean and need to be processed for high molecular weight gDNA extraction. We are currently experiencing difficulties in obtaining clean fungal cultures free from soil-derived contaminants. Because all of our samples originate from field surveys, they are naturally associated with diverse soil microorganisms.

Recently, we have observed that these contaminants are increasingly tolerant/resistant to the antibiotics we have available for culture purification, which makes the clean-up process more challenging.

At the same time, repeated subculturing during antibiotic treatment is not a viable long-term solution, as excessive transfers increase the risk of inducing genetic changes in the fungus due to prolonged exposure to harsh, antibiotic-rich conditions. To minimize this risk, we limit the clean-up process to a maximum of five subculture attempts to preserve the original characteristics of the isolate as closely as possible. If the culture remains contaminated after the fifth attempt, we must return to the original isolate and restart the purification process.

We have implemented a range of clean-up strategies and will continue refining our approach to improve culture purity while maintaining isolate integrity. ▪

Table 1. Disease incidences observed in dry bean fields surveyed in 2025.

State	County	Fields per County	Pinto	Navy	Black	Kidney	Cranberry	Root rot	CBB	BS	HB	White Mold	Rust
Minnesota	Becker	1	0	1	0	0	0	1	1	1	0	1	0
	Hubbard	6	1	2	0	2	1	6	6	6	1	5	0
	Otter Tail	3	0	1	0	2	0	3	3	2	1	3	0
North Dakota	Grand Forks	5	2	3	0	0	0	5	4	0	0	5	0
	Pembina	11	7	4	0	0	0	11	7	0	0	11	0
	Trail	3	1	1	1	0	0	3	3	0	0	3	0
	Walsh	1	1	0	0	0	0	1	0	0	0	0	0
Total Fields		30	12	12	1	4	1	30	24	9	2	28	0

	2nd sampling timepoint							
Field	State	Start Date	End Date	Growth Stage	Common Bacterial Blight disease incidence (in % out of 100 plants)	Halo Blight disease incidence (in % out of 100 plants)	Bacterial Brown Spot disease incidence (in % out of 100 plants)	White Mold disease incidence (in % out of 100 plants)
1	ND	07/29/2025	07/31/2025	R1	3	0	0	3
2	ND	07/29/2026	07/31/2026	R2	0	0	0	0
3	ND	07/29/2027	07/31/2027	R4	0	0	0	14
4	ND	07/29/2028	07/31/2028	R2	9	0	0	16
5	ND	07/29/2029	07/31/2029	R2	22	0	0	0
6	ND	07/29/2030	07/31/2030	R4	0	0	0	22
7	ND	07/29/2031	07/31/2031	R2	0	0	0	8
8	ND	07/29/2032	07/31/2032	R4	0	0	0	16
9	ND	07/29/2033	07/31/2033	R2	0	0	0	0
10	ND	07/29/2034	07/31/2034	R4	39	0	0	30
11	ND	07/29/2035	07/31/2035	R3	0	0	0	11
12	ND	07/29/2036	07/31/2036	R3	10	0	0	0
13	ND	07/29/2037	07/31/2037	R4	0	0	0	1
14	ND	07/29/2038	07/31/2038	R4	22	0	0	7
15	ND	07/29/2039	07/31/2039	R3	5	0	0	2
16	ND	07/29/2040	07/31/2040	R3	20	0	0	10
17	ND	07/29/2041	07/31/2041	R4	39	0	0	0
18	ND	07/29/2042	07/31/2042	R4	1	0	0	4
19	ND	07/29/2043	07/31/2043	R3	39	0	0	2
20	ND	07/29/2044	07/31/2044	R3	20	0	0	6
21	MN	07/29/2045	07/31/2045	R4	11	0	1	2
22	MN	07/29/2046	07/31/2046	R3	4	0	14	2
23	MN	07/29/2047	07/31/2047	R3	72	0	10	0
24	MN	07/29/2048	07/31/2048	R4	50	1	3	1
25	MN	07/29/2049	07/31/2049	R3	14	0	12	1
26	MN	07/29/2050	07/31/2050	-	-	-	-	-
27	MN	07/29/2051	07/31/2051	R3	78	0	0	4
28	MN	07/29/2052	07/31/2052	R3	52	0	24	17
29	MN	07/29/2053	07/31/2053	R2	50	3	15	2
30	MN	07/29/2054	07/31/2054	R3	9	2	5	0
31	MN	07/29/2055	07/31/2055	R2	64	0	2	0

	3rd sampling timepoint					
Field	State	Start Date	End Date	Growth Stage	White Mold disease incidence (in % out of 100 plants)	Rust
1	ND	08/19/2025	08/27/2025	R7	37	0
2	ND	08/19/2026	08/27/2026	R7	38	0
3	ND	08/19/2027	08/27/2027	R6	7	0
4	ND	08/19/2028	08/27/2028	R6	1	0
5	ND	08/19/2029	08/27/2029	R7	24	0
6	ND	08/19/2030	08/27/2030	R7	20	0
7	ND	08/19/2031	08/27/2031	R6	0	0
8	ND	08/19/2032	08/27/2032	R6	20	0
9	ND	08/19/2033	08/27/2033	R7	10	0
10	ND	08/19/2034	08/27/2034	R7	2	0
11	ND	08/19/2035	08/27/2035	R7	21	0
12	ND	08/19/2036	08/27/2036	R7	0	0
13	ND	08/19/2037	08/27/2037	R8	2	0
14	ND	08/19/2038	08/27/2038	R7	25	0
15	ND	08/19/2039	08/27/2039	R7	4	0
16	ND	08/19/2040	08/27/2040	R6	10	0
17	ND	08/19/2041	08/27/2041	R7	70	0
18	ND	08/19/2042	08/27/2042	R7	0	0
19	ND	08/19/2043	08/27/2043	R6	33	0
20	ND	08/19/2044	08/27/2044	R6	0	0
21	MN	08/19/2045	08/27/2045	R6	50	0
22	MN	08/19/2046	08/27/2046	R6	36	0
23	MN	08/19/2047	08/27/2047	R6	0	0
24	MN	08/19/2048	08/27/2048	R7	17	0
25	MN	08/19/2049	08/27/2049	R6	7	0
26	MN	08/19/2050	08/27/2050	R7	66	0
27	MN	08/19/2051	08/27/2051	R6	44	0
28	MN	08/19/2052	08/27/2052	R6	89	0
29	MN	08/19/2053	08/27/2053	R5	56	0
30	MN	08/19/2054	08/27/2054	-	-	-
31	MN	08/19/2055	08/27/2055	R7	36	0

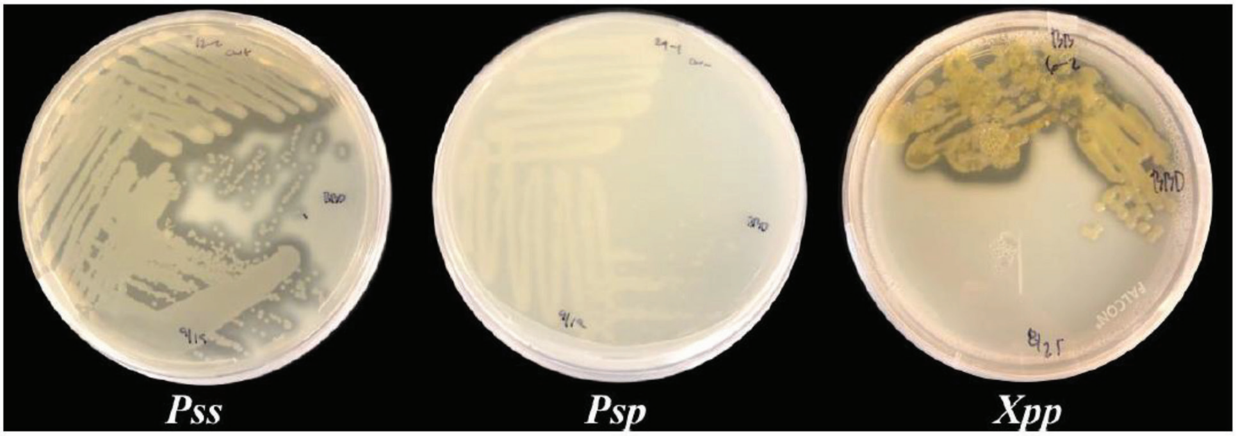


Figure 1. Bacterial isolates on differential media (BBD). Pss colonies appear white, with Pss having clear borders resulting from milk protein breakdown that are not present for Psp colonies, which are unable to break down milk protein. Yellow Xpp colonies also exhibit the same clearing zones.

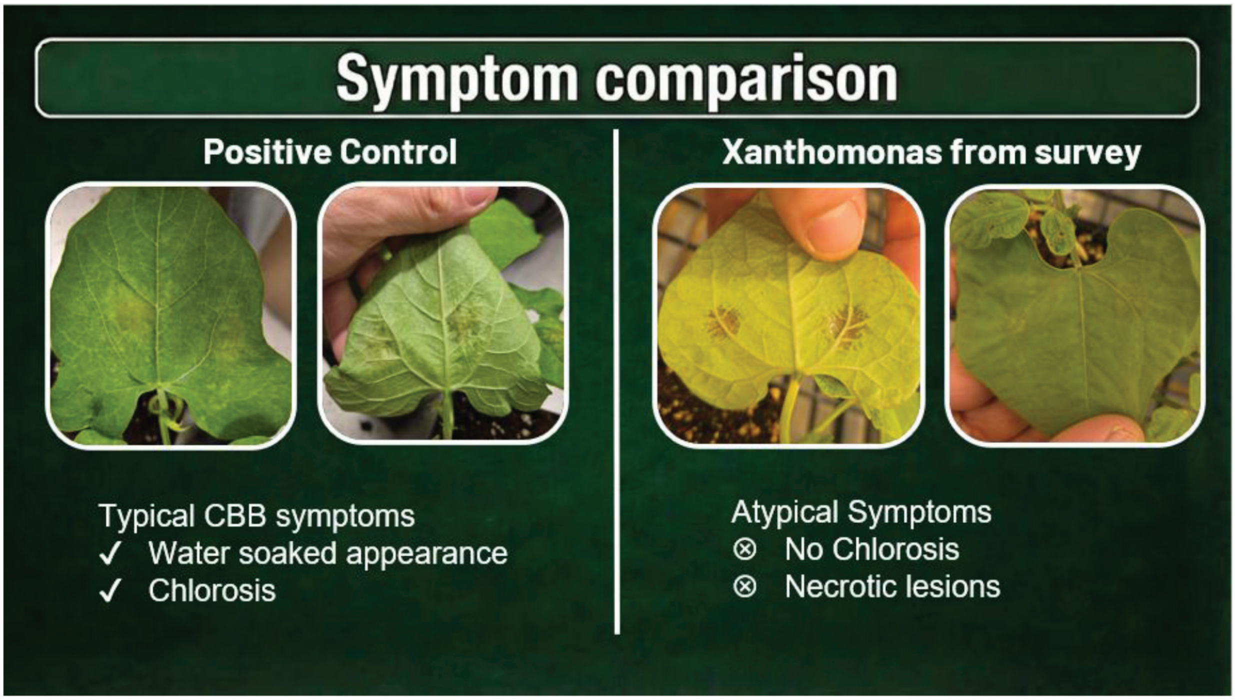


Figure 2. Comparison of typical CBB symptoms caused by *Xanthomonas phaseoli* pv. *phaseoli* to the symptom phenotype caused by the *Xanthomonas* isolates from the 2025 survey.

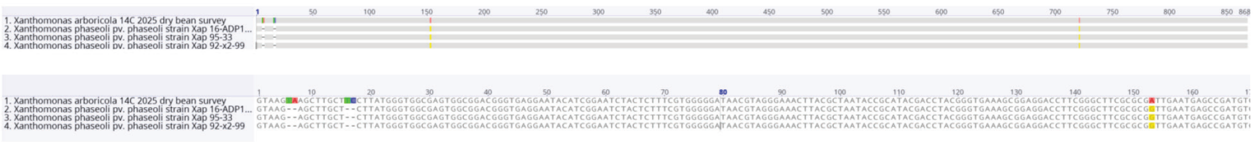


Figure 3. Alignment of one of the *Xanthomonas arboricola* (top) and 3 previously sampled *Xanthomonas phaseoli* pv. *phaseoli* (below). A) 868 bp long sequences of the bacterial 16S region, difference in sequences are indicated by color. B) zoomed in the first 170 bp of the sequences to better visualize that the top *Xanthomonas arboricola* sequence has 2 insertions and 2 SNPs (exchanges of base pairs) compared to the 3 *Xanthomonas phaseoli* pv. *phaseoli* sequences. This proves that the *Xanthomonas arboricola* is different from the bean-infecting *Xanthomonas phaseoli* pv. *phaseoli sequences.*

Figure 4. Symptoms of Xanthomonas arboricola on stone fruit (adapted from Han et al. (2021)) resemble the symptoms that the Xanthomonas arboricola isolates collected from our bean survey show when inoculated on dry bean.

References

Han V-C, Yu NH, Park AR*, et al.*, 2021. First Report of Shot-Hole on Flowering Cherry Caused by Burkholderia contaminans and Pseudomonas syringae pv. syringae. *Plant Disease* **105**, 3795-802.

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Improving White Mold Management in Dry Beans

Recent field trials reveal that white mold management hinges on a strategic tradeoff: while a single fungicide application is most effective when delayed until 70% to 100% pin-pod development, multi-spray programs require significantly earlier intervention to protect emerging canopy.

"The optimal fungicide application timing and the optimal number of days between fungicide applications change with the number of applications being made."
– Michael Wunsch, Research Plant Pathologist

Project update – major findings:

The fungicide application timing, frequency and interval research collaboratively funded by Northarvest and by the ND Crop Protection Product Harmonization and Registration Board (Minor Use Fund) in 2024 and 2025 has been highly informative. The results from the first two years of field research, together with prior fungicide application timing work conducted with a single versus two sequential fungicide applications, indicate the following:

1. **The optimal application timing of fungicides targeting white mold changes with the number of applications being made**. In research studies conducted utilizing supplemental irrigation to create conditions favoring white mold as dry beans enter bloom, white mold management was optimized with a single fungicide application by delaying the application until 70-100% of plants had initial pin-pods. Two-application fungicide programs were optimized by applying the first application a few days earlier, when 10-85% of plants had initial pin-pods. Three-application fungicide programs were optimized by applying the first application at early bloom when 0-5% of plants had initial pin-pods.
2. **The optimal application interval (number of days between applications) changes with the number of applications being made, severity of white mold pressure, and maturity length of the dry bean variety.** In kidney beans, three-application fungicide programs were consistently optimized when applications were made approx. 7 days apart, and two-application fungicide programs were

optimized when applications were made approx. 7 or 10 days apart, depending on white mold risk. The tighter application interval was optimal when white mold risk was highest. In pinto beans, three-application fungicide programs were optimized when applications were made approx. 7 or 10 days apart, and two-application fungicide programs were optimized when applications were made approx. 10 or 12 days apart, depending on white mold risk. The tighter application interval was optimal was white mold risk was highest.

3. **White mold management (disease control, yield) improves as the number of fungicide applications increases.** Realizing the full gain from an additional fungicide application requires adjustments in application timing and application interval. Three-application fungicide programs were most effective when the first application was made at initial bloom when 0-5% of plants had initial pin-pods and when the interval between applications was tight (generally approx. 7 days).
4. **Rotating fungicide chemistries in two- and three-application fungicide programs improves white mold management.** When including Topsin/generic or ProPulse in a fungicide program targeting white mold, field testing conducted on pinto and kidney beans in 2026 and prior testing suggests that the efficacy of Topsin is sharply increased as the application rate increases from 30 to 40 fl oz/ac and that ProPulse is most effective when it is applied first (and other products applied second and/or third) in a fungicide rotation program.

Development of rigorous recommendations requires multiple years of testing to facilitate assessment of treatment responses across diverse environments. This proposal requests funding for a third year of fungicide application interval, frequency and timing research in pinto and kidney beans and a first year of such research in black and navy beans.

Explanation for the observed response to fungicide application timing:

Fungicide applications only protect the canopy that is present at the time of the application. The fungicide does not translocate into new growth and does not protect the new growth that occurs after the fungicide is applied. If you are making a single fungicide application, there is a tradeoff: Do you protect against a few early infections or do you delay the application such that more of the canopy is protected as the dry beans enter full bloom and maximum susceptibility to white mold? The data from our field studies show that you maximize the yield gain from a single fungicide application by delaying the application until 70-100% of plants with pin-pods. This means that you are making a decision to allow some early white mold infections (that occur prior to that growth stage) in order to protect more of the canopy as the dry beans reach maximum susceptibility to white mold. Delaying the application in order to protect more of the canopy reduces the number and severity of infections occurring during full bloom.

When you are making two fungicide applications, the first application should be made a few days earlier than would be optimal in a single-application program. The second fungicide application will protect new growth, which means that now you can afford to protect the crop against early white mold infections. However, applying too early still carries a penalty for the same reason: The new growth that occurs after the first application and before the second application is unprotected until the second application is made.

With a three-application program, applications #2 and #3 protect the new growth, and our data show that the fungicide program is optimized by applying the first fungicide just before the first plants become susceptible to white mold. In other words, you can now afford to protect against the earliest infections because you are making subsequent applications on a relatively tight interval to protect the new growth.

Progress report - methods:

The impact of fungicide application timing, interval and frequency was tested in Carrington, ND in 2024 and 2025 with a PTO-driven tractor-mounted sprayer equipped with a pulse-width modulation system (Capstan AG; Topeka, KS). Testing was conducted on the pinto bean varieties 'Torreton' in 2024 and 'ND Rodeo' in 2025 and on the kidney bean varieties 'Pink Panther' in 2024 and 'Epic' in 2025. Pulse width was modified as needed to achieve the target spray volume while maintaining a constant driving speed across droplet size or spray volume treatments differing in nozzle output, with pulse width calibrated on the basis of measured output immediately before spraying treatments. Fungicide droplet size (medium or coarse) was calibrated relative to canopy characteristics, driving speed was 6.0 mph, and spray volume was 15 gal/ac. The same fungicide (Endura 8 oz) was applied in every application due to logistical constraints. To permit overspray of plots, treatment plots were bordered by 5- or 10-foot wide non-harvested plots. On ends of each treatment plot, a non-harvested plot was established to permit turning on and off the sprayer at full driving speed.

Experimental design was a completely randomized split-plot (main factor = fungicide application interval and frequency, sub-factor = fungicide application timing) with nine replicates. The efficacy of different fungicide rotation sequences in two- and three-application fungicide programs was tested with a hand-held spray boom. Experimental design was a randomized complete block with 8 replicates, and separate studies were conducted for each market class (pinto bean, cv. 'ND Rodeo'; kidney beans, cv. 'Pink Panther'). Fungicide droplet size (medium or coarse) was calibrated relative to canopy characteristics and spray volume was 15 gal/ac.

Testing was conducted on pinto and kidney beans seeded at 90,000 viable seeds/ac in rows 14 inches apart. In all testing, white mold was assessed by scoring every plant individually in one row per plot (2025) or two rows per plot (2024) for white mold severity. Plants were clipped at the base to simulate knifing, wind-rowed, and lifted into the plot combine. To ensure that lodging did not influence bias the yields, the dry beans were not straight-harvested. Yields were calculated on the basis of the measured harvested plot length and grain moisture at harvest and reported at a standard 13.5% moisture. ▪

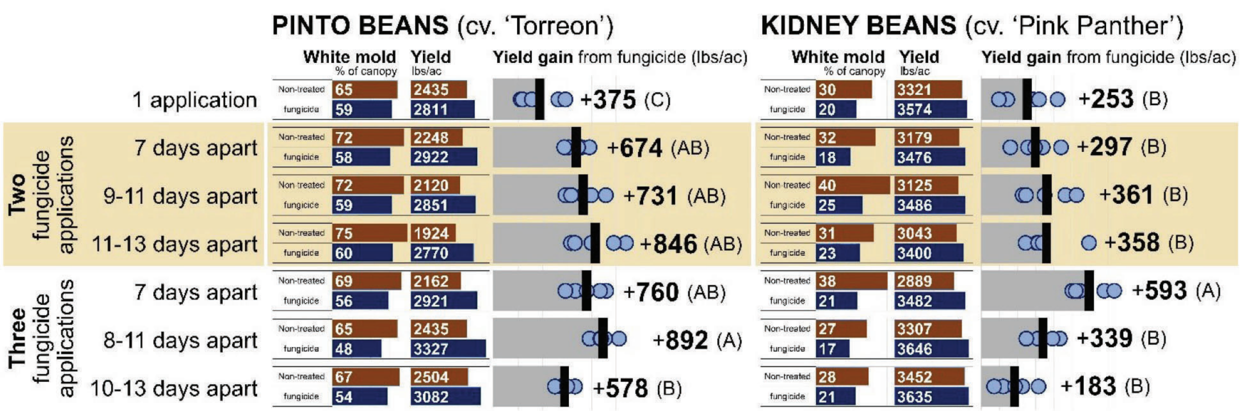


Figure 1. Response to fungicide application timing, interval and frequency in kidney and pinto beans; 14-inch rows, 90,000 seeds/ac, Carrington, ND (2024). Bars denote the average across five fungicide application timings; circles denote the response in individual studies.

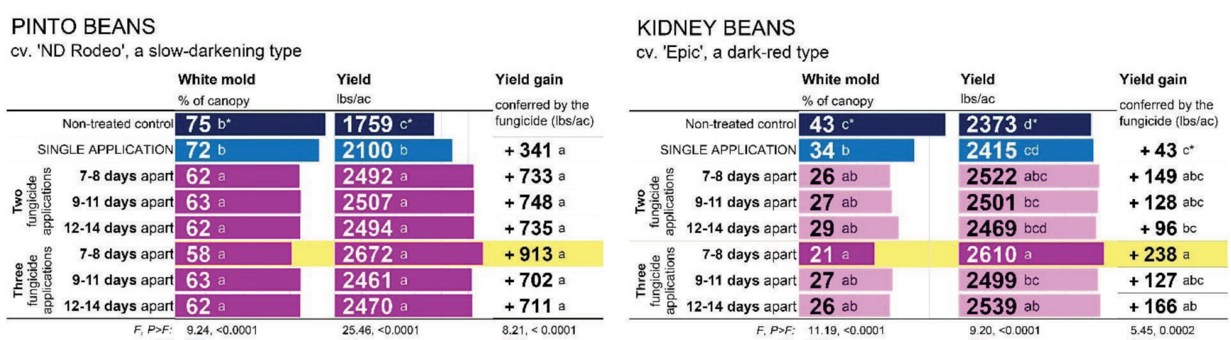


Figure 2. Response to fungicide application timing, interval and frequency in kidney and pinto beans; 14-inch rows, 90,000 seeds/ac, Carrington, ND (2025). Bars denote the average across five fungicide application timings.

Figure 3. Impact of fungicide application rate and sequence; Carrington (2025). 'ND Rodeo' pintos and 'Pink Panther' LR kidneys; 14" rows, 90,000 seeds/ac.

	White mold (% of canopy) – Market class: PINTO	White mold – Market class: KIDNEY	White mold – Average across both market classes	Yield (lbs/ac) – Market class: PINTO	Yield – Market class: KIDNEY	Yield – Average across both market classes
Non-treated control	79 d*	49 d*	64 c*	1196 d*	2422 c*	1809 b*
TWO APPLICATIONS (kidney beans, 9 days apart; pinto beans, 13 days apart)						
Topsin 30 fl oz / **Topsin** 30 fl oz	66 bcd	34 bcd	50 bc	1904 bc	2890 ab	2397 ab
Topsin 40 fl oz / **Endura** 8 oz	60 abc	31 a-d	46 ab	2162 abc	2894 ab	2528 ab
ProPulse 10.3 fl oz / **Topsin** 40 fl oz	60 abc	19 abc	39 ab	2281 abc	3062 ab	2672 ab
THREE APPLICATIONS with Topsin @ 30 fl oz/ac applied twice						
Topsin 30 fl oz / **Topsin** 30 fl oz / **Endura** 8 oz	62 abc	30 a-d	46 abc	2311 abc	2772 bc	2541 ab
Topsin 30 fl oz / **Endura** 8 oz / **Topsin** 30 fl oz	70 cd	25 abc	48 abc	1838 cd	3029 ab	2434 ab
Endura 8 oz / **Topsin** 30 fl oz / **Topsin** 30 fl oz	58 abc	29 a-d	43 ab	2346 abc	2897 ab	2622 ab
THREE APPLICATIONS with Topsin @ 40 fl oz/ac applied once						
Topsin 40 fl oz / **Endura** 8 oz / **Endura** 8 oz	57 abc	37 cd	47 abc	2371 abc	2926 ab	2648 ab
Topsin 40 fl oz / **Endura** 8 oz / **ProPulse** 10.3 fl oz	56 abc	20 abc	38 ab	2217 abc	3082 ab	2649 ab
Omega 8 fl oz / **Topsin** 40 fl oz / **Endura** 8 oz	50 ab	17 abc	34 ab	2457 abc	3071 ab	2764 ab
Omega 8 fl oz / **Topsin** 40 fl oz / **ProPulse** 10.3 fl oz	56 abc	16 abc	36 ab	2682 a	3079 ab	2880 ab
ProPulse 10.3 fl oz / **Topsin** 40 fl oz / **Endura** 8 oz	48 a	12 ab	30 a	2543 ab	3168 a	2856 ab
ProPulse 10.3 fl oz / **Endura** 8 oz / **Topsin** 40 fl oz	49 a	11 a	30 a	2711 a	3101 ab	2906 a
F, P>F:	6.43, <0.0001	5.79, <0.0001	8.72, <0.0001	8.18, <0.0001	6.13, <0.0001	2.79, 0.0442
CV:	16.3	47.4	10.6	17.9	7.1	6.7

* Within-column means followed by different letters are significantly different ($P < 0.05$; Tukey multiple comparison procedure)

Growth stage at the first fungicide application: **Pinto beans:** 80% of plants with an open blossom, 50% with initial pods, 85% canopy closure.
Kidney beans: 100% of plants with an open blossom, 95% with initial pods, 95% canopy closure.

Number of days between fungicide applications: **Two-application programs:** fungicides were applied 9 days apart in kidney beans; 13 days apart in pinto beans.
Three-application programs: fungicides were applied 6-7 days apart in kidney beans; 9-11 days apart in pintos.

Optimizing fungicide application timing: pinto beans

(1) Pinto beans with an open canopy:
Average canopy closure < 95% at 70-85% plants with initial pods

Combined analysis across 5 studies

	Plants with initial pods	White mold % of canopy		Yield pounds/ac		Yield gain (lbs/ac) from the fungicide
	Non-treated	50	c	2223	c	
One application	0-5%	49	bc	2315	bc	+92 (B)
One application	11-36%	47	abc	2346	bc	+123 (B)
One application	42-66%	44	ab	2445	ab	+222 (AB)
One application	69-84%	42	a	2575	a	+352 (A)
	Non-treated	51	b	2194	b	
Two applications 8-14 days apart	0-5%	38	a	2704	a	+510 (A)
Two applications 8-14 days apart	11-36%	38	a	2647	a	+453 (A)
Two applications 8-14 days apart	42-66%	33	a	2797	a	+603 (A)
Two applications 8-14 days apart	69-84%	35	a	2815	a	+621 (A)

Optimizing fungicide application timing: pinto beans

(2) Pinto beans with a closed canopy:
Average canopy closure > 95% at 10-20% plants with initial pods

Combined analysis across 3 studies

	Plants with initial pods	White mold % of canopy		Yield pounds/ac		Yield gain (lbs/ac) from the fungicide
	Non-treated	87	b	1254	bc	
One application	0-5%	88	b	1194	c	-60
One application	10-20%	82	a	1643	ab	+389
One application	60-80%	82	a	1671	a	+417
One application	100%	78	a	1681	a	+427
	Non-treated	87	c	1254	d	
Two applications 10-12 days apart	0-5%	80	b	1717	c	+463
Two applications 10-12 days apart	10-20%	73	a	2248	a	+994
Two applications 10-12 days apart	60-80%	75	ab	2043	ab	+789
Two applications 10-12 days apart	100%	77	b	1777	bc	+486

Figure 4. Impact of fungicide application timing on white mold management in pinto beans for a single fungicide application, the first of two applications 8 to 14 days apart, or the first of three applications approx. 7 or 10 days apart.

PINTO BEANS: In a three-application fungicide program targeting white mold, optimal application timing for the 1st application was initial bloom
Endura (8.0 oz/ac) was applied at each application; spray volume = 15 gpa; driving speed = 6.0 mph

Three applications, approximately 7 days apart

PINTO BEANS **(2025)** cv. **'ND Rodeo'**

Date of first application	Plants in bloom (%)	Plants with pin-pods (%)	White mold % of canopy (3 applications 7-8 days apart)	Yield lbs/ac (3 applications 7-8 days apart)
Non-treated			79 b*	1778 b*
July 23	19	0	54 a	2804 a
July 26	66	6	61 a	2588 a
July 30	84	42	58 a	2727 a
July 31	92	69	59 a	2559 a
		F, P>F:	6.94, <0.0001	22.43, <0.0001
		CV:	31.5	6.7

PINTO BEANS **(2024)** cv. **'Torreon'**

Date of first application	Plants in bloom (%)	Plants with pin-pods (%)	White mold % of canopy (3 applications 5-8 days apart)	Yield lbs/ac (3 applications 5-8 days apart)
Non-treated			69 b*	2162 b*
July 17	3	0	54 a	3080 a
July 19	19	0	51 a	3030 a
July 24	100	49	59 ab	2921 a
July 26	100	81	59 ab	2747 a
			5.99, 0.0003	9.46, < 0.0001
			12.6	11.6

Combined analysis across studies

Plants in bloom (%)	Plants with pin-pods (%)	White mold % of canopy (3 applications 5-8 days apart)	Yield lbs/ac (3 applications 5-8 days apart)	Yield gain conferred by fungicide (lbs/ac)
Non-treated		74 b	1970 b	
3-19%	0%	54 a	2942 a	+ 973
19-66%	0-6%	56 a	2809 a	+ 839
84-100%	42-49%	58 ab	2824 a	+ 854
92-100%	69-81%	59 ab	2653 a	+ 683
	F, P>F:	8.30, 0.0322	46.74, 0.0013	
	CV:	6.3	3.0	

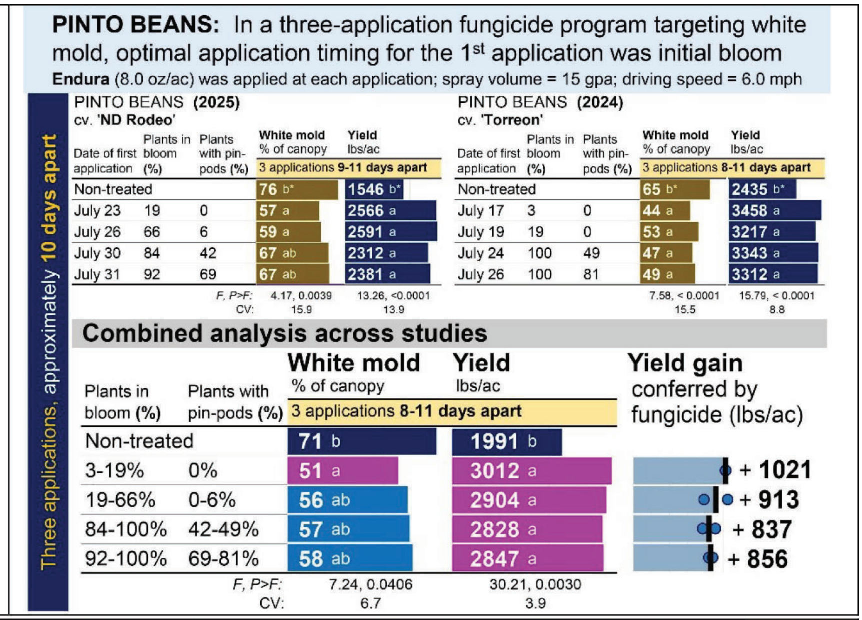
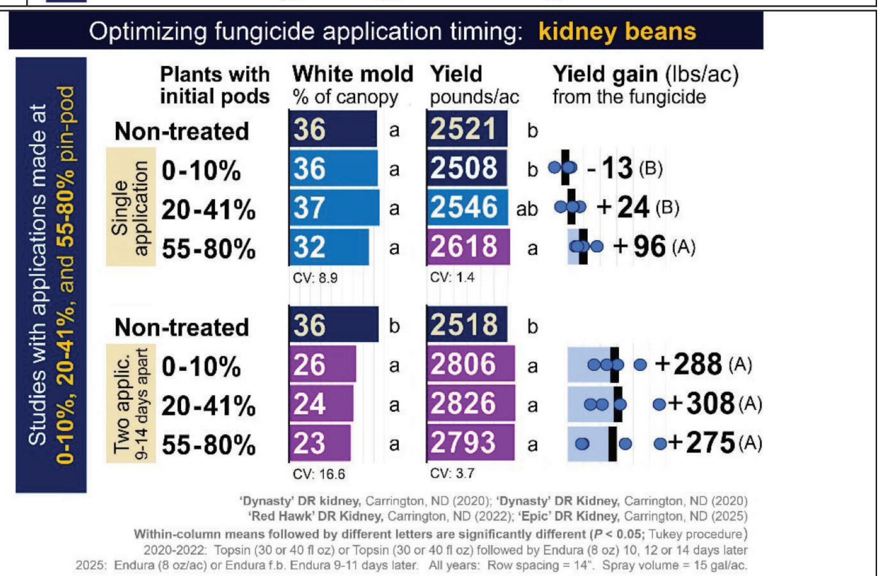
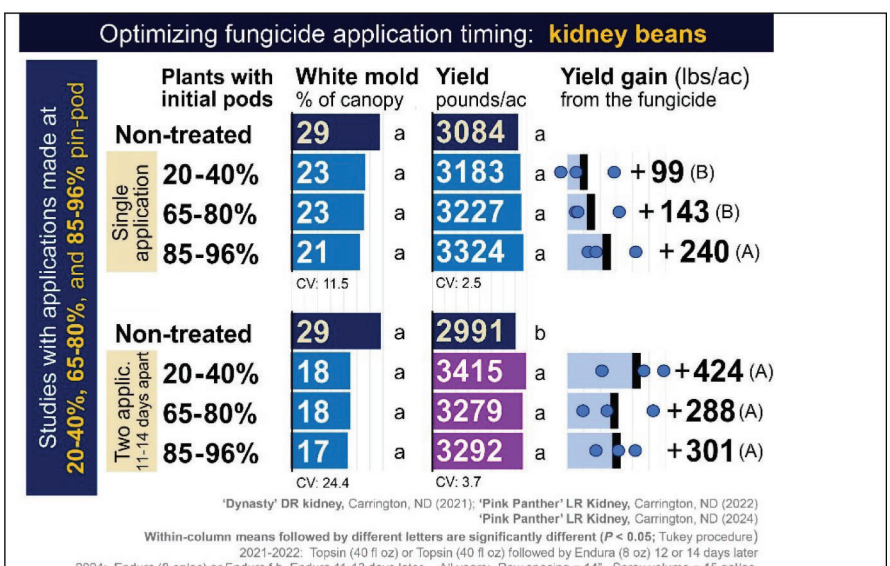


Figure 4. Impact of fungicide application timing on white mold management in kidney beans for a single fungicide application, the first of two applications 8 to 14 days apart, or the first of three applications approx. 7 or 10 days apart.





Fungicide application timing, interval & frequency: kidney beans

KIDNEY BEANS:
In a three-application fungicide program targeting white mold, optimal application timing for the 1st application was initial bloom

Carrington, ND (2025)
Endura (8.0 oz/ac) was applied at each application; spray volume = 15 gpa; driving speed = 6.0 mph

KIDNEY BEANS
cv. 'Epic', a dark-red type

Growth stage when first fungicide application was made: Application date	Canopy closure (%)	Plants in bloom %	Plants with initial pods %	White mold % of canopy (3 APPLICATIONS, 7-8 days apart)	Yield lbs/ac (3 APPLICATIONS, 7-8 days apart)	White mold % of canopy (3 APPLICATIONS, 9-11 days apart)	Yield lbs/ac (3 APPLICATIONS, 9-11 days apart)
Non-treated control				47 a*	2430 a*	48 c*	2320 b*
July 23	92%	27%	0%	17 a	2595 a	22 a	2489 ab
July 26	90%	57%	7%	17 a	2611 a	24 ab	2499 ab
July 28	93%	80%	14%	21 a	2601 a	26 ab	2471 ab
July 30	94%	95%	41%	25 a	2551 a	29 ab	2573 a
July 31	94%	99%	63%	26 a	2694 a	33 b	2465 ab
F, P>F:				16.67, <0.0001	2.32, 0.0607	19.33, <0.0001	2.50, 0.0462
CV:				31.5	6.7	20.8	6.3

* Within-column means followed by different letters are significantly different ($P < 0.05$; Tukey multiple comparison procedure)

Managing Herbicide-Resistant Ragweed in Dry Beans

NDSU Research Explores Integrated Strategies for Controlling Resistant Common Ragweed

As herbicide-resistant common ragweed becomes more widespread, growers may need to look beyond herbicides alone for long-term control.

WRITTEN BY: **EMMA RIEKE**

Herbicide-resistant common ragweed continues to create challenges for dry bean growers across the region, particularly as resistance to Groups 2 and 14 herbicides becomes more common. In field trials conducted at North Dakota State University, Dr. Joe Ikley, extension weed specialist in the Department of Plant Sciences, evaluated multiple herbicide programs to determine which combinations provided the most effective control under dry bean production conditions.

The research found that preplant incorporated mixtures containing EPTC, followed by timely postemergence applications including sequential treatments of bentazon and fomesafen, provided some of the strongest results in the study. However, Ikley noted that herbicides alone are unlikely to provide a long-term solution.

"Common ragweed that is resistant to Groups 2 and 14 herbicides will require additional weed management strategies beyond herbicides," Ikley said. "Other strategies could include extending the length of crop rotation or delaying dry bean planting since ragweed is an early emerging weed."

The study also suggests that cultural practices, including narrower row spacing than the 30-inch spacing used in the trials, may further improve weed suppression when paired with effective herbicide programs. ▪

Herbicide Programs to Control Group 2 + 14 - Resistant Common Ragweed

FY 2026 Year-End Technical Report Northarvest Bean Council

Principal Investigator:
Dr. Joseph T. Ikley, NDSU Extension Weed Scientist

Background

Common ragweed was reported as one of the three worst weeds in dry beans according to the 2022 NDSU Dry Bean Survey (Knodel et al. 2023). Common ragweed is one of the more competitive broadleaf weeds in the region, and populations have been confirmed with resistance to Group 2 + 9 + 14 herbicides (Ikley et al. 2025). A population with resistance to Groups 2 and 14 would leave two registered herbicides with activity on ragweed: EPTC (Fair) and bentazon (Poor to Fair). With no single ingredient providing effective control of common ragweed, tankmixtures and sequential programs should be evaluated to determine if these populations can be controlled in-season with herbicides.

Objective 1

Determine effectiveness of tank-mixtures of labeled dry bean herbicides applied PPI and/or PRE: Efficacy ratings in weed control guides and product labels are based on the individual active ingredient applied alone. Tank-mixtures need to be evaluated for control of Group 2 + 14 -resistant common ragweed to determine the best combination to control these populations. This objective will be met with one trial evaluating tank-mixtures applied PPI and/or PRE for common ragweed control prior to dry bean emergence. For residual control, we would evaluate combinations of EPTC (Eptam), pendimethalin (Prowl), ethalfluralin (Sonalan), trifluralin (Treflan), metolachlor (Dual), and dimethenamid-P (Outlook), halosulfuron (Permit), and sulfentrazone (Spartan) applied PPI, PRE, or PPI/PRE as product labels allow. Even though the population is resistant to Groups 2 + 14, experience with resistance in other weeds suggest that herbicides from those groups may provide some benefit to weed control. Herbicide efficacy and crop injury ratings will be recorded every 2 weeks after planting until crop canopy to determine the length of residual of these product combinations.

Treatments:

1. Eptam – 4.5 pt/A PPI
2. Sonalan – 4.5 pt/A PPI
3. Treflan – 2 pt/A PPI
4. Prowl H2O – 3 pt/A PPI
5. Dual Magnum – 2 pt/A PPI
6. Outlook – 21 fl oz/A PPI
7. Permit – 0.67 oz/A PPI
8. Spartan Charge – 5 fl oz/A PPI
9. 9 Eptam + Sonalan – 3 + 3 pt/A PPI
10. 1Eptam + Sonalan fb Permit – 3 + 3 pt/A PPI fb 0.67 oz/A PRE
11. Eptam + Sonalan fb Spartan Charge – 3 + 3 pt/A PPI fb 5 fl oz/A PRE
12. Permit + Spartan Charge – 0.67 oz/A + 5 fl oz/A PPI
13. Permit + Spartan Charge – 0.67 oz/A + 5 fl oz/A PRE
14. Eptam + Sonalan + Permit + Spartan Charge – 3 + 3 pt/A + 0.67 oz/A + 5 fl oz/A PPI
15. Eptam + Sonalan fb Permit + Spartan Charge – 3 + 3 pt/A PPI fb 0.67 oz/A + 5 fl oz/A PRE
16. Nontreated Check

Results:

Trial was planted at a research site near Wolverton, MN on May 28, 2025. The site has a sandy loam soil with 4% OM and a pH of 8.2. ND Palomino beans were seeded at a rate of 80,000 seed per acre, at a depth of 2-inches, in 30-inch rows. Herbicide treatments were all applied the same day of planting. The PPI treatments were applied and worked in with a rototiller prior to planting, and the preemergence treatments were applied directly after planting.

"Common ragweed that is resistant to Groups 2 and 14 herbicides will require additional weed management strategies beyond herbicides. Other strategies could include extending the length of crop rotation or delaying dry bean planting since ragweed is an early emerging weed." – Dr. Joe Ikley, Extension Weed Specialist

Table 1. Dry bean injury and common ragweed control at 28, 42, and 56 days after planting in 2025.[a]

Treatment[b]	28 days after planting		42 days after planting		56 days after planting	
	Dry Bean Injury (%)	Ragweed Control (%)	Dry Bean Injury (%)	Ragweed Control (%)	Dry Bean Injury (%)	Ragweed Control (%)
1	0	80 A	0	39 AB	0	23 BCD
2	0	48 BC	0	25 BCDE	0	8 DE
3	0	30 CD	0	15 DE	0	0 E
4	0	23 D	0	10 E	0	5 DE
5	0	33 CD	0	8 E	0	0 E
6	0	55 B	0	25 BCDE	0	13 CDE
7	0	28 CD	0	5 E	0	0 E
8	0	35 BCD	0	13 DE	0	8 DE
9	0	78 A	0	33 ABCD	0	18 BCDE
10	0	78 A	0	38 ABC	0	35 AB
11	0	81 A	0	48 A	0	35 AB
12	0	28 CD	0	5 E	0	3 DE
13	0	35 BCD	0	18 CDE	0	15 BCDE
14	0	76 A	0	50 A	0	45 A
15	0	76 A	0	38 ABC	0	30 ABC
16	0	0 E	0	0 F	0	0 E
	NS		NS		NS	

[a]Means followed by same letter within a column are not difference based on Fischer's LSD at α=0.05.

[b]Treatment number corresponds to herbicide, rate, and application method listed within the treatment list under Objective 1.

No dry bean injury was observed during this experiment. The greatest common ragweed control at 28 days after planting (DAP) was provided by Eptam alone (80% control), and the 5 treatments that contained Etpam + Sonalan applied PPI (76 to 81% control). Outlook applied PPI provided 55% control, and no other combination of products provided over 50% control at 28 DAP. The lack of control from Permit and Spartan Charge help confirm this population is resistant to Groups 2 and 14 herbicides.

By 42 DAP, Eptam + Sonalan + Permit + Spartan Charge all applied PPI provided the greatest level of common ragweed control (50%). All other treatments containing Eptam provided similar levels of control. These results confirm that applications of Eptam (EPTC) applied PPI provide the greatest control from residual herbicides on this common ragweed population.

Objective 2

Determine effectiveness of tank-mixtures of labeled dry bean herbicides applied POST: Bentazon (Basagran) is the only labeled herbicide with efficacy on common ragweed that is not also a Group 2 or 14 herbicide. Without an available genetic test to know if individual ragweed plants are resistant to Groups 2 and 14, tank-mixtures should be evaluated for control of the population. Tank-mixtures of bentazon (Basagran), halosulfuron (Permit), and fomesafen (Reflex) applied once, or at half-rates applied sequentially, will be evaluated for their control of ragweed and injury on dry bean. Postemergence applications will be applied when common ragweed is 1 to 2 inches in height. Appropriate adjuvants will be included with each postemergence treatment. Herbicide efficacy and crop injury ratings will be recorded 1, 2, 3, 4, 5, and 6 weeks after the first postemergence applications.

Treatments:

1. Nontreated
2. Basagran 4L – 2 pt/A
3. Basagran 4L – 1 pt/A followed 7 days later by Basagran 4L at 1 pt/A
4. Reflex – 12 fl oz/A
5. Reflex – 6 fl oz/A followed 7 days later by Reflex at 6 fl oz/A
6. Permit – 0.67 oz/A
7. Basagran 4L + Reflex – 2 pt + 12 fl oz/A
8. Basagran 4L + Reflex – 1 pt + 6 fl oz/A followed 7 days later by Basagran 4L at 1 pt/A + Reflex at 6 fl oz/A
9. Basagran 4L + Reflex + Permit – 2 pt + 12 fl oz + 0.67 oz/A
10. Basagran 4L + Reflex + Permit – 1 pt + 6 fl oz + 0.67 oz/A followed 7 days later by Basagran 4L + Reflex at 1 pt + 6 fl oz/A
11. NDSU Dry bean tank-mix applied twice – Basagran 4L + Beyond Xtra + Reflex – 0.5 + 1 + 3 fl oz/A followed 7 days later by the same treatment
12. NDSU Dry bean tank-mix applied four times – Basagran 4L + Beyond Xtra + Reflex – 0.5 +1 + 3 fl oz/A followed 7 days later by the same treatment for a total of 4 applications

Results:

Trial was planted at a research site near Wolverton, MN on May 28, 2025. The site has a sandy loam soil with 4% OM and a pH of 8.2. ND Palomino beans were seeded at a rate of 80,000 seed per acre, at a depth of 2-inches, in 30-inch rows. First herbicide treatments were applied on June 19, when common ragweed was 2-inches tall, and dry bean were at third trifoliate stage. Follow up applications were applied 7, 14, or 21 days after the first application depending on the treatment.

Table 2. Dry bean injury and common ragweed control at 7, 14, and 21 days after first postemergence application in 2025.[a]

Treatment[b]	7 days after first POST		14 days after first POST		21 days after first POST	
	Dry bean Injury (%)	Ragweed Control (%)	Dry bean Injury (%)	Ragweed Control (%)	Dry bean Injury (%)	Ragweed Control (%)
1	0 E	0 D	0 E	0 G	0 B	0 E
2	19 A	23 B	11 BC	14 EF	1 B	3 DE
3	11 BC	10 C	5 DE	6 FG	0 B	0 E
4	9 BCD	25 B	6 CD	14 EF	0 B	0 E
5	8 CD	13 C	11 BC	28 CD	3 B	10 CDE
6	6 D	0 D	4 DE	0 G	0 B	0 E
7	20 A	30 AB	13 B	24 DE	4 B	5 DE
8	11 BC	23 B	23 A	43 AB	9 A	25 AB
9	23 A	35 A	14 B	28 CD	3 B	18 BC
10	13 B	35 A	23 A	48 A	9 A	35 A
11	8 CD	10 C	14 B	33 BCD	3 B	13 CD
12	6 D	13 C	20 A	36 ABC	13 A	30 A

[a]Means followed by same letter within a column are not difference based on Fischer's LSD at α=0.05.

[b]Treatment number corresponds to herbicide, rate, and application method listed within the treatment list under Objective 2.

Treatments containing the mixture of Basagran and Reflex at their full use rate, or at their half-rate plus tank-mixed with Permit, provided the greatest dry bean injury (19 to 23%) and the greatest ragweed control (30 to 35%) at 7 days after first POST treatment. Throughout the course of the trial, both dry bean and ragweed recovered from injury in plots with only one postemergence treatments.

At 14 days after first POST treatment (and 7 days after the sequential treatment), the tank-mixes with sequential applications of Basagran and Reflex provided the most dry bean injury (20 to 23%) and ragweed control (36 to 48%). By 21 days after first POST (and 14 days after the sequential treatment), dry bean injury was reduced to 9 to 13%, while common ragweed control was reduced to 25 to 35% as both species recovered from herbicide injury. Individual application of Permit did not affect common ragweed, confirming Group 2 herbicides are not effective POST on this application. From a postemergence standpoint, no combination of treatments provided effective control on this Group 2 + 14 resistant population.

Objective 3

Determine effectiveness of season-long ragweed control of tank-mixtures of labeled dry bean herbicides applied in a program: Herbicides will be evaluated as a residual plus foliar program to determine if complete ragweed control can be obtained using herbicides. This program approach is important given that residual herbicides can often set up foliar applications for better weed control. Previous research has indicated that EPTC can reduce the cuticle thickness of plants, which could help improve effectiveness of POST herbicides (Flore and Bukovac 1974). This would also imply a thinner cuticle on dry bean plants, so dry bean injury will be evaluated in addition to ragweed control. By combining PPI, PRE, and POST tankmixtures, the goal will be to find a combination that controls ragweed and provides acceptable safety to the crop. POST treatments will be applied when common ragweed reaches 2 inches in height. Herbicide efficacy and crop injury ratings will be recorded 1, 2, and 4 weeks after POST applications. Yield will be collected.

Treatments:

1. Eptam + Sonalan at 3 + 3 pt/A PPI, Reflex at 12 fl oz/A POST
2. Eptam + Sonalan at 3 + 3 pt/A PPI, Basagran 4L + Reflex at 2 pt + 12 fl oz/A POST
3. Eptam + Sonalan at 3 + 3 pt/A PPI, Permit at 0.67 oz/A PRE, Reflex at 12 fl oz/A POST
4. Eptam + Sonalan at 3 + 3 pt/A PPI, Permit at 0.67 oz/A PRE, Basagran 4L + Reflex at 2 pt + 12 fl oz/A POST
5. Eptam + Sonalan at 3 + 3 pt/A PPI, Spartan Charge at 5 fl oz/A PRE, Permit at 0.67 oz/A POST
6. Eptam + Sonalan at 3 + 3 pt/A PPI, Spartan Charge at 5 fl oz/A PRE, Reflex at 12 fl oz/A POST
7. Eptam + Sonalan at 3 + 3 pt/A PPI, Spartan Charge at 5 fl oz/A PRE, Permit + Reflex at 0.67 oz + 12 fl oz/A POST
8. Eptam + Sonalan at 3 + 3 pt/A PPI, Spartan Charge at 5 fl oz/A PRE, Basagran 4L + Permit + Reflex at 2 pt + 0.67 oz + 12 fl oz/A POST
9. Eptam + Sonalan at 3 + 3 pt/A PPI, Permit + Spartan Charge at 0.67 oz + 5 fl oz/A PRE, Reflex at 12 fl oz/A POST
10. Eptam + Sonalan at 3 + 3 pt/A PPI, Permit + Spartan Charge at 0.67 oz + 5 fl oz/A PRE, Basagran 4L + Reflex at 2 pt + 12 fl oz/A POST
11. Eptam + Sonalan + Permit + Spartan Charge at 3 pt + 3 pt + 0.67 oz + 5 fl oz/A PPI, Reflex at 12 fl oz/A POST
12. Eptam + Sonalan + Permit + Spartan Charge at 3 pt + 3 pt + 0.67 oz + 5 fl oz/A PPI, Basagran 4L + Reflex at 2 pt + 12 fl oz/A POST
13. Nontreated

Results

Trial was planted at a research site near Wolverton, MN on May 28, 2025. The site has a sandy loam soil with 4% OM and a pH of 8.2. ND Palomino beans were seeded at a rate of 80,000 seed per acre, at a depth of 2-inches, in 30-inch rows. Residual herbicide treatments were all applied the same day of planting. The PPI treatments were applied and worked in with a rototiller prior to planting, and the preemergence treatments were applied directly after planting. Postemergence herbicides were applied on June 24, when common ragweed plants were 2-inches tall.

Table 3. Dry bean injury and common ragweed control at 28, 35, and 42 days after planting in 2025.[a]

Treatment[b]	35 days after planting/ 7 days after POST		42 days after planting/ 14 days after POST		56 days after planting/ 28 days after POST	
	Dry bean	Ragweed	Dry bean	Ragweed	Dry bean	Ragweed
	Injury (%)	Control (%)	Injury (%)	Control (%)	Injury (%)	Control (%)
1	13 B	80 AB	5 E	73 AB	0	50 ABC
2	28 A	80 AB	11 BCDE	76 AB	0	48 BC
3	10 B	76 B	5 E	69 BC	0	44 BC
4	25 A	88 A	10 CDE	83 A	0	56 ABC
5	10 B	64 C	13 ABCDE	56 C	0	39 C
6	13 B	80 AB	11 BCDE	75 AB	0	53 ABC
7	15 B	81 AB	16 ABCD	76 AB	0	54 ABC
8	28 A	84 AB	16 ABCD	83 A	0	68 A
9	15 B	84 AB	18 ABC	80 AB	0	55 ABC
10	25 A	90 A	20 A	84 A	0	68 A
11	10 B	83 AB	9 DE	80 AB	0	49 ABC
12	26 A	89 A	19 AB	83 A	0	63 AB
13	0 C	0 D	0 F	0 D	0	0 D

[a]Means followed by same letter within a column are not difference based on Fischer's LSD at α=0.05.

[b]Treatment number corresponds to herbicide, rate, and application method listed within the treatment list under Objective 3.

Crop injury was within the same numbers as objectives 1 and 2, where injury was mainly caused by postemergence herbicides. At the 35 day after planting (7 days after postemergence application), treatments with Eptam + Sonalan + Permit + Spartan Charge applied PPI and/or at planting, followed by the tank-mix of Basagran and Reflex provided the greatest control (89 to 90%). Most other treatments provided similar levels of control (80 to 84%). The treatment with least control was the treatment that only contained Permit applied postemergence (64%).

Common ragweed control declined for all treatments, and by 28 days after postemergence no combination of products provided 70% or greater. Yield was collected at the end of the season, and there were no differences amongst treatments, including the non-treated check. None of the tested programs were able to provide season-long common ragweed control on this population with resistance to Groups 2 and 4 herbicides.

These trials will be repeated in the 2026 growing season to confirm results. Future research could also focus on planting dry bean in narrow-rows to facilitate earlier canopy closure and help maintain levels of weed control observed at the 7 day after POST rating in objective 3. Objective 3 could also be expanded to include multiple POST applications to extend the levels of control later into the season. Other non-chemical options like harvest weed seed control, cover crops, or chemical electrocution of common ragweed are also viable research pathways for this and similar Group 2 + 14 -resistant populations. ▪

How Dry Beans Stack Up Against SCN

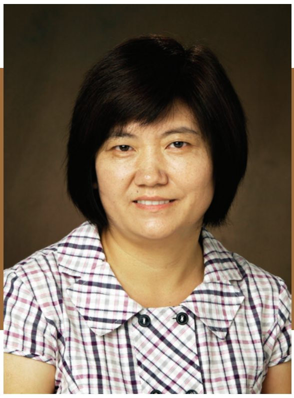
New Field Research Sheds Light on Resistance and Future Management Strategies

Dry bean varieties and breeding lines tested for resistance to SCN in a naturally infested field trial at the North Dakota Prosper Research Site in 2025.

As soybean cyst nematode (SCN) continues to spread, its impact on dry beans is becoming harder to ignore. This study evaluated multiple dry bean varieties and breeding lines in naturally infested fields, revealing a wide range of responses. While some lines showed promise in limiting SCN reproduction, most supported population growth, reinforcing the need for resistant varieties and proactive management.

Soybean cyst nematode (SCN) continues to spread across the region, creating new challenges for dry bean production. At North Dakota State University, Dr. Guiping Yan and Dr. Sam Markell are working to better understand how dry bean varieties perform under natural field pressure, evaluating both breeding lines and commercial varieties in SCN-infested soils. ▪

"Dry bean varieties and breeding lines exhibited variable responses to soybean cyst nematode (SCN) infection under field conditions. "– Dr. Yan



Evaluation of Dry Bean Breeding Lines and Varieties for Resistance to Soybean Cyst Nematode in Field Trials

Dr. Guiping Yan, Plant Nematologist, Dr. Sam Markell, Extension Plant Pathologist, Dr. Juan M. Osorno, Dry Bean Breeder, and Kapil Simkhada, Graduate Student, North Dakota State University

Soybean cyst nematode (SCN; Heterodera glycines Ichinohe) is recognized as the most economically damaging pathogen of soybean (Glycine max L.) in the US. This microscopic, soilborne plant-parasitic nematode is responsible for estimated annual soybean yield losses of more than $1.5 billion nationwide. Since its first detection in North Carolina in 1954, SCN has progressively spread to nearly all major soybean-producing states. In North Dakota, SCN was initially identified in Richland County in 2003 and has since expanded to most soybean-growing counties, with egg population densities varying widely among fields. The distribution and egg levels of SCN in North Dakota between 2013 and 2025 are presented in Supplementary Figure 1.

SCN spreads primarily through the movement of infested soil by equipment, wind, water, animals, or contaminated seed. Once established in a field, complete eradication is virtually impossible due to the nematode's durable survival mechanisms. Mature SCN females attached to infected roots, can each produce up to 500 eggs. As females age, their bodies harden into cysts that encase and protect the eggs, enabling them to survive in soil for many years under adverse environmental conditions. Importantly, infestations and yield reductions often occur without obvious above-ground symptoms. When visible symptoms such as chlorosis, stunting, or wilting become apparent, yield losses of 15-30% may have already occurred. Because these symptoms resemble those caused by nutrient deficiencies, soil compaction, drought stress, or fungal pathogens, visual diagnosis is unreliable. Therefore, soil sampling remains the most effective and dependable method for detecting and quantifying SCN populations. Sampling is typically conducted before planting or around harvest.

Dry bean (Phaseolus vulgaris L.) is another suitable alternative host to SCN. Studies conducted by Poromarto and Nelson in 2009 from North Dakota State University (NDSU) have shown that SCN infection can reduce dry bean yield by more than 50%. In 2017, PI Yan et al. first reported the presence of SCN in a commercial dry bean field in Minnesota, which gives evidence of growing population of SCN in the region. Host plant resistance is the primary and most sustainable means of managing SCN populations. While the SCN resistance in soybeans is well documented, its interaction with dry beans is comparatively limited. Among the few research projects focused on SCN in dry beans, the majority have been conducted under controlled greenhouse conditions (Poromarto and Nelson 2009, Jain et al. 2019). Scientific field trials in naturally infested soils are needed to gain a comprehensive understanding of host responses to nematode infestation under different environmental conditions.

Hence, in this study, we conducted a field experiment in 2025 to evaluate 12 dry bean varieties and breeding lines along with two soybean checks (one resistant and one susceptible) under naturally SCN-infested field conditions. Additionally, a growth chamber experiment was performed using inoculum collected from the same field to assess their resistance responses under controlled conditions.

OBJECTIVES

1. Identify field sites with SCN and evaluate dry bean breeding lines and varieties from the NDSU dry bean breeding program for their resistance to SCN in the infested field.
2. Compare their responses to SCN infection in the field conditions with greenhouse conditions.
3. Enhance growers' education on SCN in dry beans.

MATERIALS AND METHODS

This research was carried out in 2025 at Prosper Research Site located in Cass County, ND to evaluate resistance of 12 dry bean genotypes (2 varieties and 10 breeding lines),

"This study provides the first evaluation of SCN resistance in dry beans under naturally infested field conditions. The findings underscore the need to develop dry bean varieties with improved SCN resistance and to promote the use of resistant varieties for effective nematode disease management." – Dr. Yan

along with two soybean lines (one resistant check and one susceptible check), against SCN under natural field conditions. The selected dry bean genotypes represent multiple market classes (Kidney, Great Northern, Black, Pinto, and Slow Darkening Pinto). The field experiment consisted of 70 plots arranged in a randomized complete block design with five replications. Prior to planting (May 31), soil samples were collected from each plot to determine the initial SCN population density (Pi) by taking ten soil cores in a zigzag pattern, compositing them per plot, and storing them under cold conditions. A 100-cc subsample from each composite was processed for cyst extraction using standard sieving and decanting methods and eggs were extracted from cysts and counted under a compound microscope. At harvest (October 2), soil samples were collected from the rhizospheric region of 10 randomly selected plants per plot, composited, processed similarly, and eggs were quantified to determine the final population density (Pf). The reproduction factor (RF) was calculated as Pf/Pi for each plot, where RF > 1 indicates nematode population increase (susceptibility), RF ≈ 1 indicates maintenance of the population, and RF < 1 indicates reduced reproduction (resistance).

Field-recovered SCN populations were increased in the greenhouse by inoculating eggs onto the susceptible soybean cultivar 'Barnes' grown in pots. After sufficient nematode multiplication, cysts were collected and eggs were extracted to serve as inoculum. A growth chamber experiment in the greenhouse was then conducted to evaluate resistance of the 12 dry bean genotypes and determine the HG type of the SCN population using standard procedures. For each dry bean entry and soybean checks, 7-8 seeds were germinated for 5-6 days, and uniform seedlings were transplanted individually into cone-tainers filled with autoclaved river sand soil with four replications (one plant per pot). Each plant was inoculated with 2,000 SCN eggs near the root zone at planting. Plants were maintained at 27°C with a 16-hour photoperiod and watered daily. After 30 days, SCN females were extracted from soil and roots and counted under a dissecting microscope. Female Index (FI) was calculated as: FI = (average number of females on a test line / average number of females on the susceptible check 'Barnes') × 100. The FI values were used to categorize resistance levels: FI < 10% = Resistant (R); FI = 10-30% = Moderately Resistant (MR); 30% < FI ≤ 60% = Moderately Susceptible (MS); and FI > 60% = Susceptible (S).

RESULTS

Objective 1 (Evaluation of breeding lines and varieties for resistance to SCN in field trials). The Reproduction Factor (RF) values differed significantly among treatments (Supplementary Figure 2), ranging from 0.45 to 7.33, indicating clear variation in host response to SCN. Out of the 14 total entries tested (12 dry bean genotypes and 2 soybean checks), 11 entries exhibited RF values greater than 1, indicating that SCN populations increased during the growing season. The susceptible soybean check supported the highest nematode reproduction, providing biological validation of the inoculum viability and infection pressure in the field. In contrast, three entries (NDSU-BL-4, NDSU-BL-10 and soybean resistant check) had RF values less than 1, indicating suppression of SCN reproduction.

These dry bean lines along with the susceptible and resistant soybean checks were also evaluated with the field-SCN population under controlled greenhouse conditions. Differences in Female Index (FI) values among the treatments were statistically significant (Supplementary Figure 3), ranging from 10.7 % to 69.6 %, demonstrating substantial variation in SCN reproduction among genotypes. The susceptible soybean check exhibited the highest FI, and the resistant soybean check recorded the lowest FI. Two dry bean lines, NDSU-BL-4 and NDSU-BL-10 were classified as MR showing significantly reduced nematode reproduction compared to highly susceptible entries. The remaining dry bean entries fall within the MS category, indicating that although their reproduction was significantly lower than the susceptible soybean check, they still supported SCN development. Additionally, the SCN population recovered from the field soil was determined to be HG type 0 based on the HG type testing.

Objective 2 (Compare their responses to SCN infection in the field conditions with greenhouse conditions). The Pearson correlation was conducted, and it indicates a strong positive relationship (r= 0.93) between Female Index (FI) obtained from the greenhouse experiment and Reproduction Factor (RF) measured under field conditions. This suggests that genotypes exhibiting higher nematode reproduction in the controlled growth chamber assay also tend to support greater SCN reproduction in the field, and lines with low FI generally show low RF. This result obtained in the first year (2025) indicates the reliability of the greenhouse FI assay as a predictive tool for field performance and supports the combined use of FI and RF in accurately identifying stable SCN-resistant genotypes.
Objective 3 (Enhance growers' education on SCN in dry beans). Grower and grower-advisor education was conducted in the first year in two primary ways, 1) direct contact with growers at Extension events and 2) indirect contact with growers through the agricultural media. Seven events were conducted with 362 grower and/or grower advisor audience members. One event was 100% virtual and targeted to growers (138 attendees), three events were specific to crop advisors (116 attendees total), two events were delivered to NDSU Extension agents and specialists with the intent to multipy the message to growers (58 attendees), and one event was a field day delivered to early career scouts/students (50 attendees). Indirect contact with growers was done in

partnership with the Red River Farm Radio Network in the growing season; beginning (May), end (October), and future planning (late November). The RRFRN delivers to 23 stations in ND, MN and SD, but does not report specific audience reach.

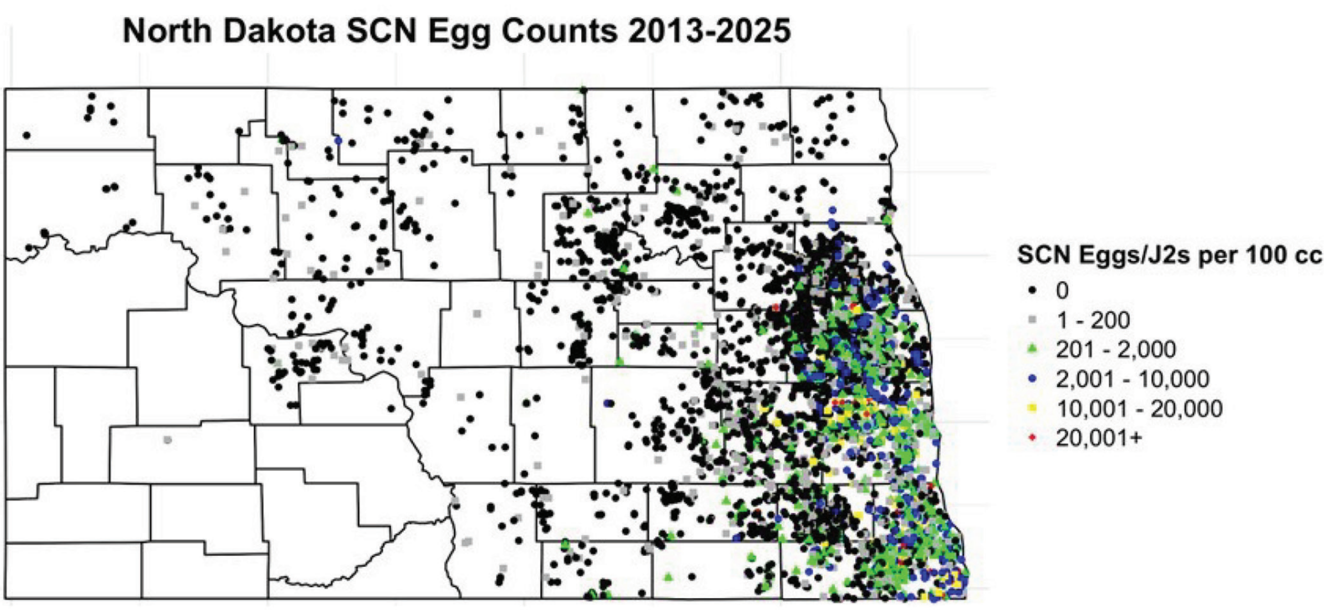
DISCUSSION

This study represents the first evaluation of SCN resistance in dry bean germplasm under naturally infested field conditions in North Dakota, addressing a critical gap in nematode management. Although SCN is traditionally associated with soybeans, the majority of dry bean lines evaluated supported nematode reproduction in both field and controlled growth chamber assays. However, none exhibited susceptibility comparable to the susceptible soybean check. Under field conditions, two breeding lines suppressed SCN reproduction, performing similarly to the resistant soybean check. A strong positive correlation observed in the first year between the female index (FI) from the greenhouse assay and the reproduction factor (RF) from the field trial suggests that greenhouse screening is a predictive tool of field performance, supporting its integration into dry bean breeding programs targeting SCN resistance. The experiments will be repeated in 2026 to validate the consistency of these responses and to confirm the reactions of the evaluated varieties and breeding lines to SCN infection.

Identification of resistant or tolerant genotypes will facilitate the development of dry bean varieties with enhanced resistance to SCN. For growers, primary SCN management strategies include crop rotation, the use of resistant or less susceptible varieties, and application of appropriate seed treatments. Soil sampling is strongly recommended to detect the presence of SCN and to quantify egg population densities, thereby assessing production risk. SCN sampling can be done in the spring or most commonly in the fall. When SCN is detected, implementation of the above management strategies can help reduce the egg numbers in the soil and mitigate yield losses. Growers are also encouraged to consult the NDSU Dry Bean Production Guide for more information on SCN and its management recommendations.

ACKNOWLEDGEMENTS

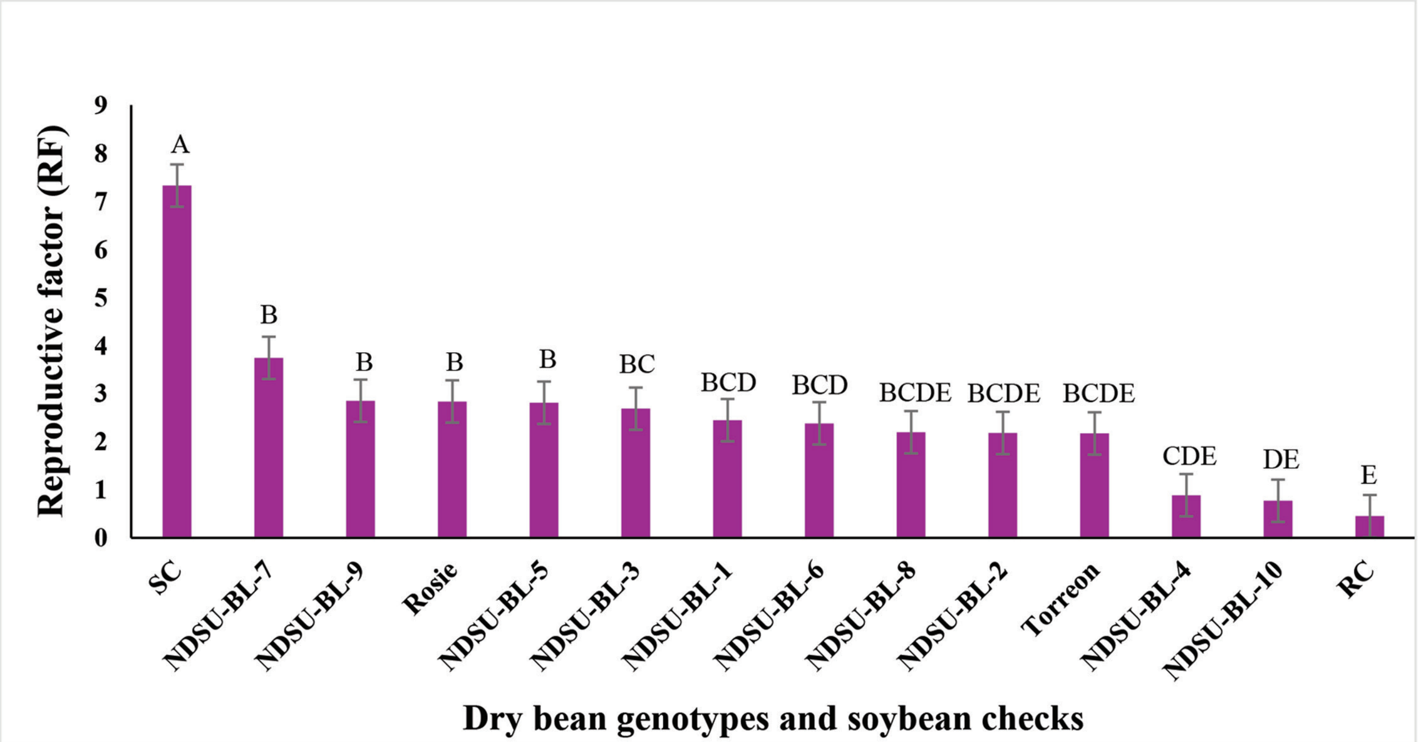
We would like to thank the Northarvest Bean Growers Association for the financial support that made this research possible. We also sincerely thank the NDSU Nematology team members for their assistance with field soil sampling for this project.



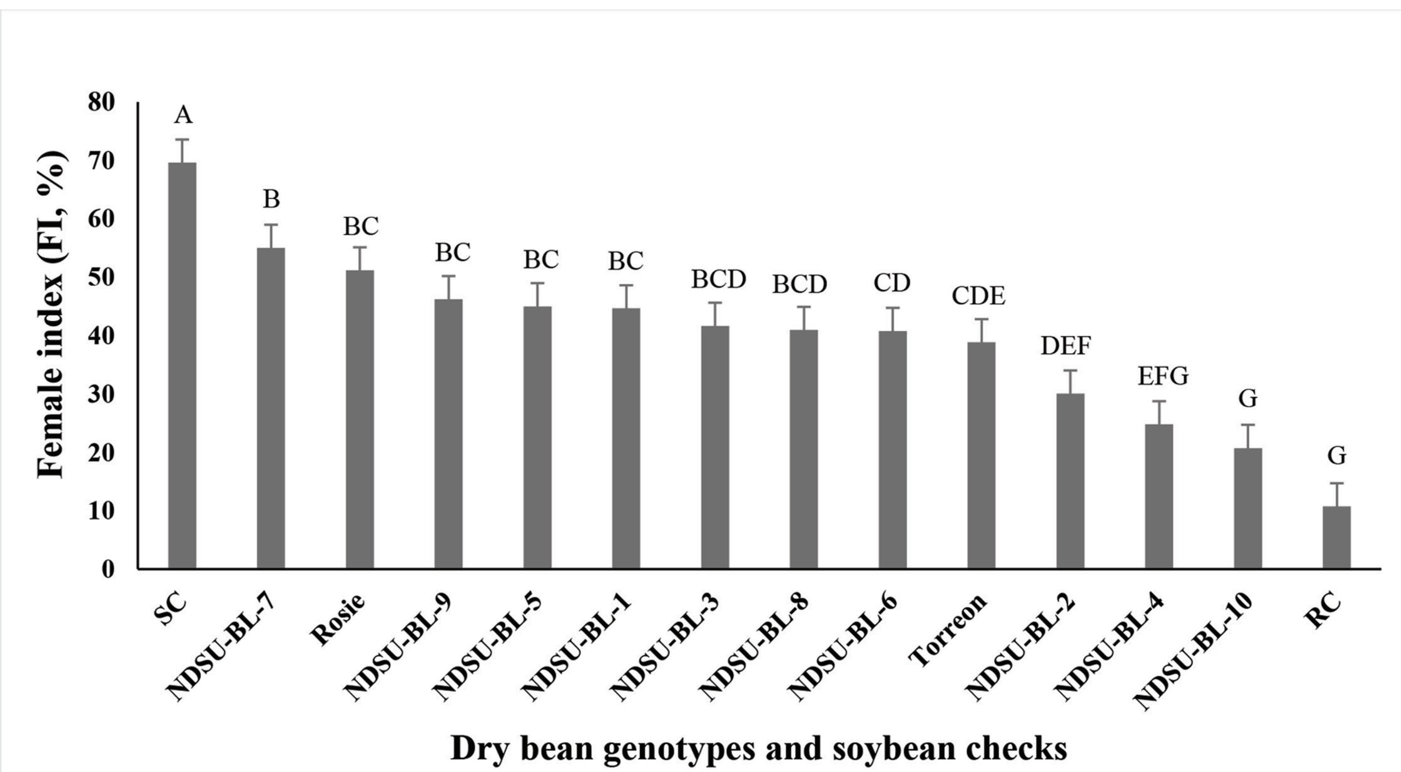
SCN Egg levels identified in soil samples submitted through NDSC/NDSU Extension sampling program from 2013-2025 (Courtesy: Dr. Wade Webster).

KEY TAKEAWAY

Dry bean varieties and breeding lines exhibited variable responses to soybean cyst nematode (SCN) infection under field conditions. This study provides the first evaluation of SCN resistance in dry beans under naturally infested field conditions. The findings underscore the need to develop dry bean varieties with improved SCN resistance and to promote the use of resistant varieties for effective nematode disease management. ▪



Reproductive factor (RF) of each of the 12 dry bean genotypes and 2 soybean checks assessed to check their resistance responses in the field trial. Lines sharing the same letter are not significantly different ($P < 0.05$). SC and RC are susceptible and resistant soybean checks, respectively. Rosie and Torreon are dry bean varieties. NDSU-BL-1 to NDSU-BL-10 are the NDSU breeding lines.



Female index (FI) of each of the 12 dry bean genotypes and 2 soybean checks assessed to check their resistance responses in controlled greenhouse conditions. Lines sharing the same letter are not significantly different ($P < 0.05$). SC and RC are susceptible and resistant soybean checks, respectively. Rosie and Torreon are dry bean varieties. NDSU-BL-1 to NDSU-BL-10 are the NDSU breeding lines.

Nitrogen Management and Biologicals in Dry Beans

NDSU Researchers Evaluate Fertilizer Rates and Nitrogen-Fixing Products Under Field Conditions

As growers look to fine-tune nitrogen management and explore the potential of biological products, questions remain about how these tools perform under real-world conditions. In Central North Dakota, a field study led by Szilvia Yuja and Dr. Qasim Khan at North Dakota State University set out to evaluate how traditional nitrogen applications and nitrogen-fixing biologicals compare, particularly in a season shaped by challenging weather.

In this Central North Dakota study, dry bean yields responded positively to nitrogen, even in a season impacted by hail. Biological products showed some promise but lacked consistent results. For now, nitrogen remains the foundation of effective fertility management, with biologicals playing a secondary role.

"Nitrogen remains essential for maximizing dry bean yield, with our results showing a positive numerical response to applied nitrogen, despite significant hail damage during the growing season," said Dr. Khan. "Biological products showed some promise but did not produce consistent or statistically significant responses in this trial. As research continues, growers should rely on proven nitrogen management strategies and view biologicals as a complementary addition rather than a replacement."

Can Nitrogen-Fixing Biologicals, Rhizobia Inoculants, and Nitrogen Fertilizers Boost Dry Bean Yields and Quality in Central North Dakota?

Szilvia Yuja, Sergio Cabello Leiva, Qasim Khan

Dry beans have a lower biological nitrogen fixation rate than other legumes, such as soybeans. Roughly only up to 50% of a dry bean plant's nitrogen comes from rhizobial nitrogen fixation, even under optimal conditions. Therefore, supplemental nitrogen is often necessary for achieving high yields and quality in dry beans in North Dakota; however, excessive nitrogen can delay maturity, increase disease risk, and reduce yields.

The market offers biological products that fix nitrogen, by colonizing leaf tissues, offering an additional or alternative pathway for symbiosis. However, their effectiveness in North Dakota's dry bean production was not previously documented in dry bean. Identifying the most suitable products for this crop is essential for improving yields and profitability.

Two leading nitrogen-fixing biological products are Envita™ from Azotic North America and Utrisha™ from Corteva Agriscience. Envita features Gluconacetobacter diazotrophicus, a bacterium that fixes nitrogen and is applied to plants via the roots, stems, or leaves. Utrisha contains Methylobacterium symbioticum, which similarly fixes nitrogen and forms a comparable relationship with plants. Both products are labeled for several different types of crops, including dry beans. This study was designed to test their efficacy at boosting dry bean yield and quality.

Trial establishment

In the growing season of 2025, a field trial was established in Carrington, ND, under a dryland conventional tillage system. The trial compared two foliar inoculants, Envita and Utrisha and a Rhizobial inoculant to an uninoculated control at three nitrogen levels: 0, 35 and 70 lbs of nitrogen per acre (Table 1). The treatments were arranged in a split-plot design with nitrogen rates as the main plot and inoculant treatments being the sub-plot effect. Each treatment combination was replicated four times. The trial used 'Lariat' pinto beans.

Table 1. Free-nitrogen fixing biological field treatments

Main Plot	**Sub-plot**	
Nitrogen treatment (lb/acre)	**Bacteria product treatment**	**Application timing**
0	**Envita**	**V4-V6 sprayed**
	Urtrisha	**V4-V6 sprayed**
	Rizhobium dry bean Inoculant	**Applied at planting with seed**
	no bacteria-based product	**-**
35	**Envita**	**V4-V6 sprayed**
	Urtrisha	**V4-V6 sprayed**
	Rizhobium dry bean Inoculant	**Applied at planting with seed**
	no bacteria-based product	**-**
70	**Envita**	**V4-V6 sprayed**
	Urtrisha	**V4-V6 sprayed**
	Rizhobium dry bena Inoculant	**Applied at planting with seed**
	no bacteria-based product	**-**

Results

The trial was heavily impacted by hail during flowering, which not only caused mechanical damage to the plants, many of which broke at the stem, but also opened up the plants to bacterial infections as evidenced by the slime that developed on and near the damaged tissues. This damage greatly increased the variability in the data, potentially obscuring treatment effects.

A split-plot analysis of the whole dataset found no significant interaction effects for any of the measured variables. For this reason, further analysis was conducted on the nitrogen rates and the biological treatments independently from each other.

Yield

Despite these setbacks, dry bean yields showed a strong positive numerical trend in response to nitrogen rates with yield increasing by approximately 2.22 lbs/A for every pound of nitrogen applied. These results at the 85% confidence level fell short of the 90% confidence level to be considered statistically significant, due to the noise in the data. The biological products had no statistically significant effect on yield. Numerically, the Rhizobia-inoculated plots and those treated with Utrisha yielded more than the check, though this effect was indistinguishable from the potential effect of random hail patterns.

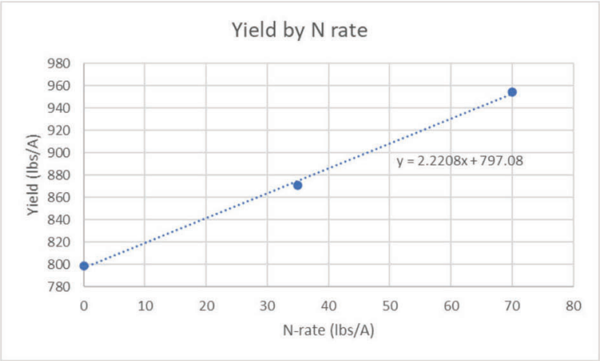


Figure 1

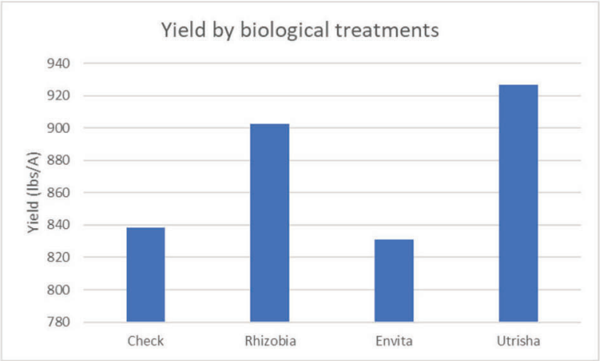


Figure 2

Protein

Grain protein remained uniform across all nitrogen rates and biological products, with no significant differences observed.

Nodule Count

Nodule counts decreased as nitrogen rates increased, with a sharp reduction at the 70 lb N rate compared to the 0 and 35 lb rates. This downward trend was statistically significant at the 0.05 p-level. While no significant differences were found between biological products, all three products resulted in numerically higher nodulation than the untreated check. However, these differences could not be reliably distinguished from random environmental effects.

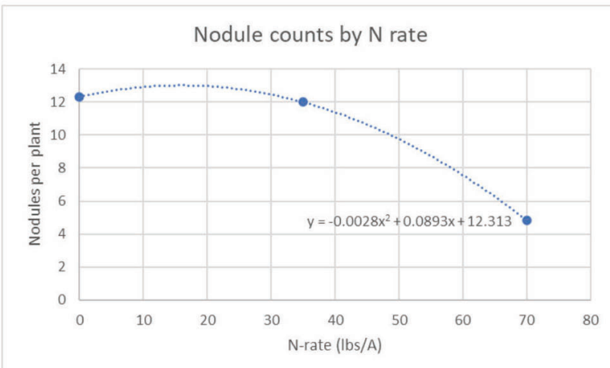


Figure 3

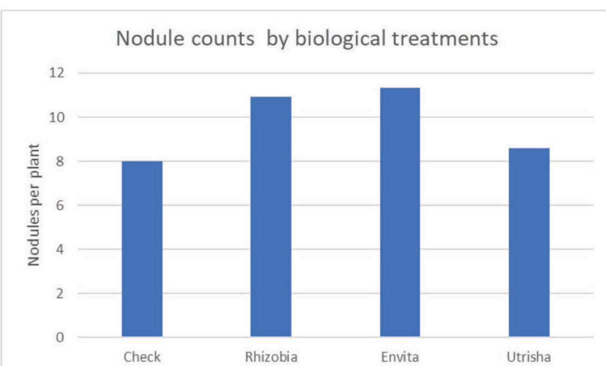


Figure 4

Summary

Hail damage introduced high variability into this trial, reducing our ability to distinguish treatment effects. Despite this, nodule counts were significantly affected by nitrogen rates, and yields showed a strong positive numerical trend in response to nitrogen. The numerical increases in yield and nodulation observed with biological products suggest it would be worthwhile to continue studying these treatments in future trials. ▪

Economic Contribution to Dry Bean Industry Report

In September of 2025, NDSU researchers Dean A. Bangsund and Nancy M. Hodur completed the report "Economic Contribution of the Dry Bean Industry in Minnesota and North Dakota." In it, the researchers sought to determine the economic impact of the industry.

Dean A. Bangsund and Nancy M. Hodur

"Government revenues demonstrate an industry's support for public services…a total of $76.3 million in state and local tax revenues was generated by the dry bean industry in Minnesota and North Dakota."

"The concentration of dry bean production and processing accentuates the industry's economic importance in rural economies in both Minnesota and North Dakota…. the economic effects of co-locating production and processing increase the crop's regional footprint."

Economic Contribution of the Dry Bean Industry in Minnesota and North Dakota:
https://ndcompass.org/wp-content/uploads/2025/11/Economic-contribution-of-dry-beans-AAE-834.pdf

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NDSU Ag Trade Monitor, Strait of Hormuz Closure

After the US and Israel launched Operation Epic Fury on February 28th, 2026, Iran retaliated by closing down the Strait of Hormuz on March 2nd. By the 4th of March, tanker traffic through the Strait has dropped to near zero. Among other issues, the scale of fertilizer supply at risk is very concerning for agriculture.


Sandro Steinbach and Shawn Arita

"Unlike the 2022 Ukraine shock, where Russian products were redirected, Gulf production behind a closed Strait has no viable alternative routing for large vessels."

"Beyond the direct disruption of urea, ammonia and phosphate exports, there is also a risk of indirect effects through sulfur ... .essential input for producing all phosphate fertilizer."

NDSU Agricultural Trade Monitor
March 2026: https://www.capts-ndsu.com/_files/ugd/3c6228_75888b0cd72f4b25a87c83496b3789fe.pdf

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