PIVOT BIO

Dynamic Research. Proven Results.

Pivot Bio is a sustainable agriculture company delivering farmers patented crop nutrition technologies that harness the power of nature to reliably and productively grow the food the world needs in the face of increasing volatility.

Challenge: Synthetic Fertilizer

2.5%

of global GHG emissions can be attributed to synthetic fertilizer

- 40-60% of applied synthetic fertilizer never reaches the plant
- Unpredictable due to leaching and volatilization
- Excess synthetic ends up as nitrates in our water & nitrous oxide as unrecoverable GHG 300x more potent than carbon dioxide
- Dangerous for farmers to handle

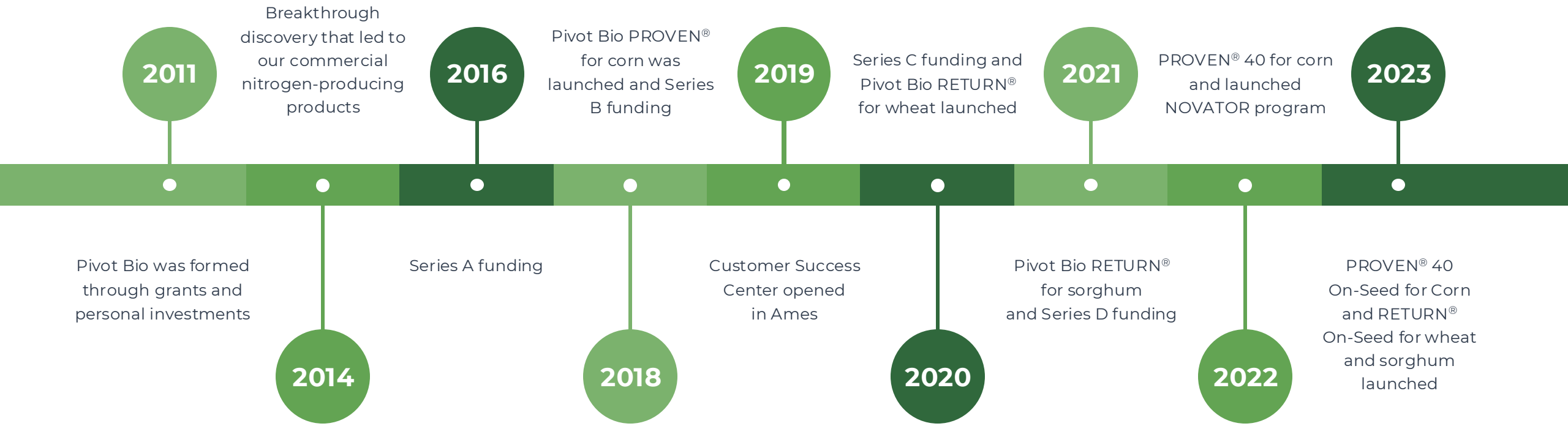
Solution: Pivot Bio

100%

of the product is available to the plant with no runoff or volatilization

- Nitrogen-fixing microbes for cereal crops, creating a more reliable, predictable and sustainable way to nourish crops.
- Highly efficient in the field with little waste, more profitable, safer to handle, manufactured in the U.S.
- Growers achieve better profitability, predictability, safety, and sustainability
- Breakthrough innovation and among the industry's most promising climate solutions

Expanding product portfolio



Pivot Bio Research Ethos

Innovation requires collaboration. Pivot Bio partners closely with leading university agriculture programs to conduct structured trials to demonstrate how our breakthrough technology maintains or improves yield. The goal? To prove that Pivot Bio's products help growers achieve greater profitability, predictability and sustainability.

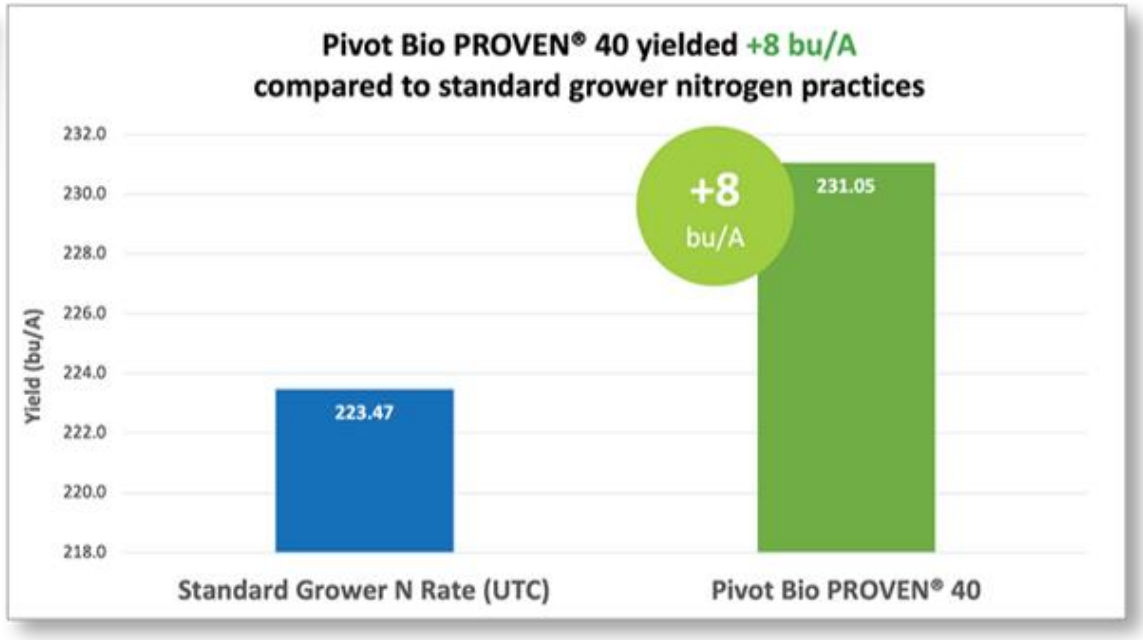
The following is a comprehensive look at an esteemed collection of over 400 university-led and additional on-farm trial locations in 2023 plus additional data supporting multi-year trials, making it one of the most significant research endeavors focused on nitrogen science in agriculture and biofertilizer inputs to date.

Pivot Bio has partnered with more than 20 research universities

University and independent research organizations report an +8 Bu/A field advantage using Pivot Bio PROVEN® 40

- Averaged across two years and 15 nitrogen rates, corn yields increased by up to **+8 bu/A** across all PROVEN 40 treatments compared to standard grower nitrogen practices.
- Results from 2021-2022 studies in 14 locations across Indiana, Iowa, Illinois, Georgia, and North Carolina.

SCAN HERE FOR COMPLETE INDEPENDENT-PERFORMANCE DATA



1. **Multi-year higher yields with less nitrogen**
   Barker Research in Iowa & Precision Planting in Illinois
2. **Decreased Nitrate Leaching**
   Iowa State University
3. **Higher potassium levels improved yield**
   Purdue University
4. **Increase Macronutrient Uptake & Greater Biomass**
   North Carolina State

2023 Third Party Collaborators

2023 THIRD PARTY COLLABORATORS

22
Universities

3
CROs

550+
2023 Trial Locations

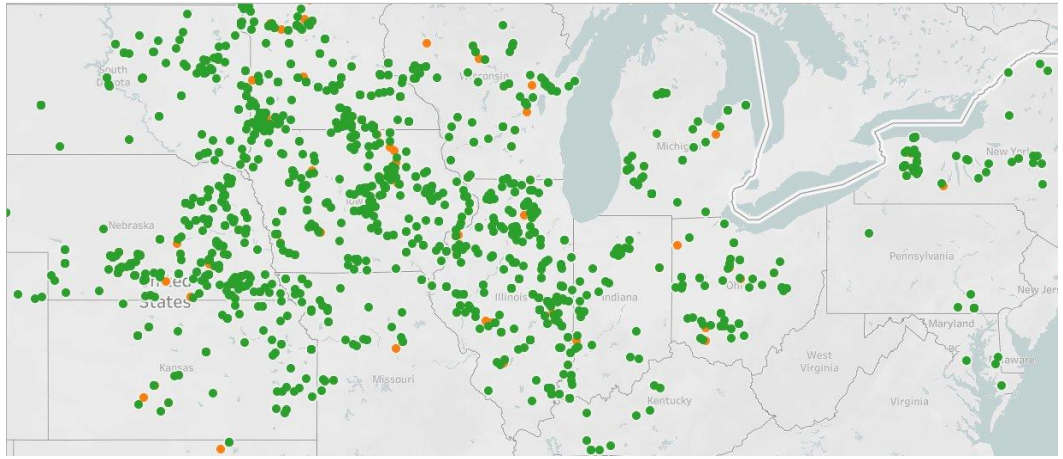
2023 UNIVERSITY TRIAL TESTING LOCATIONS

Note: Not all locations are the actual field location

2023 NATIONAL INTERNAL RESEARCH SCALE

1010
Growers Visited

1408
Field Visits



Third-Party Research Findings

PTI 3-year trial results with a 180 lb/acre synthetic N baseline compared against 130 lb Synthetic + PROVEN® 40 demonstrates yield advantage and higher ROI

2020 - 2022 Pivot Bio PROVEN® 40 Nitrogen Management Study

Research Conducted by Precision Planting

Location
Precision Planting's
Precision Technology
Institute Farm,
Central Illinois

Trial Year
2020-2022

Objective

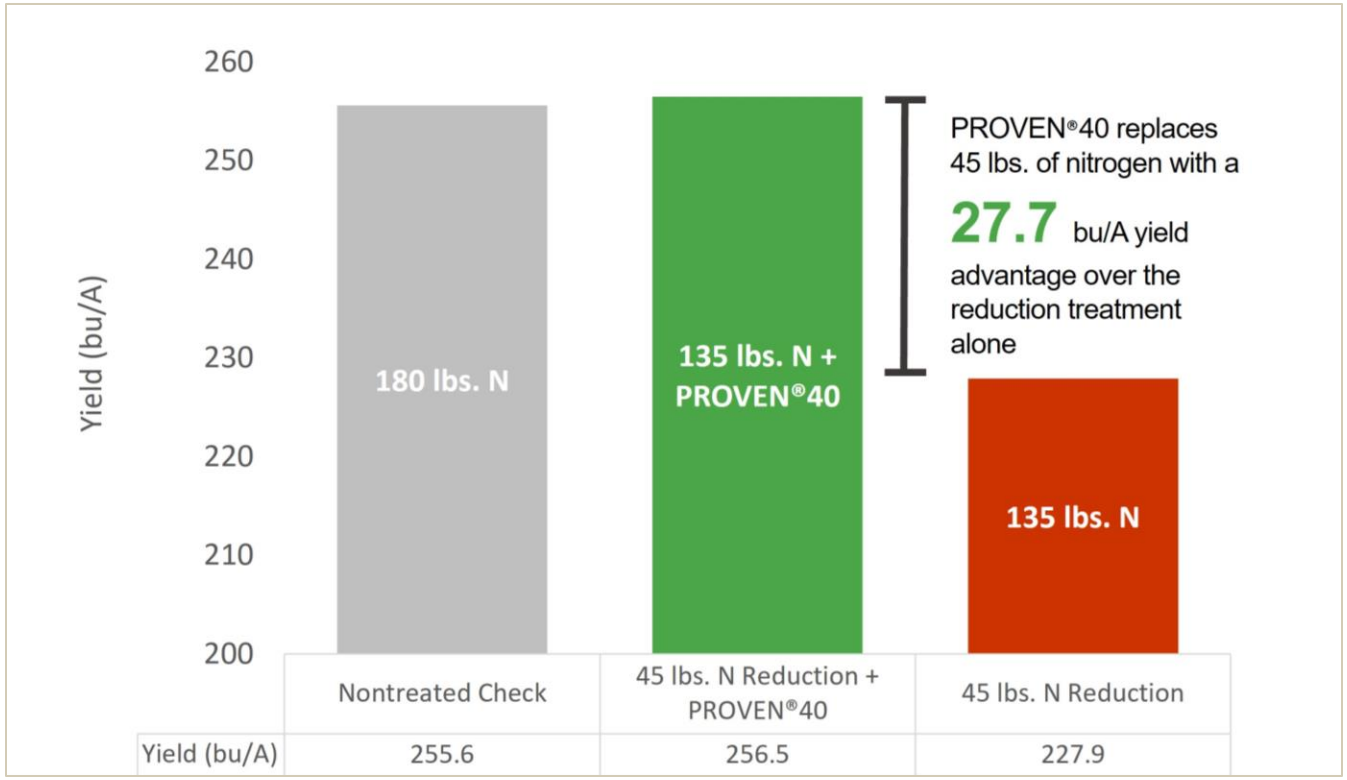
The objective of the Nitrogen Management Study is twofold:

1. Measure the effect on yield using PROVEN® 40 with 45 lbs. N reduction
2. Measure the return on investment using PROVEN® 40

Protocol	For this agronomic study, nitrogen rates are evaluated at: • 180 lbs. N – 100% full N rate (nontreated check) • 135 lbs. N – 25%/45 lbs. N reduction • 135 lbs. N – 25%/45 lbs. N reduction + PROVEN® 40
Details	• Planting Date: April 28, 2022, April 28, 2021, May 27, 2020 • Hybrid: AgriGold 639-70 (2022), DKC 66-17 (2021), DKC 59-82 (2020) • Population: 36k • Row Width: 30” • Application: In-furrow at planting via Precision Planting FurrowJet® treatments

This report has been produced by an independent 3rd party consulting firm, 9 North Group, utilizing data collected and processed by Precision Planting.

PROVEN® 40 has consistently demonstrated that N can be reduced by 45 lbs. while increasing yield and revenue.



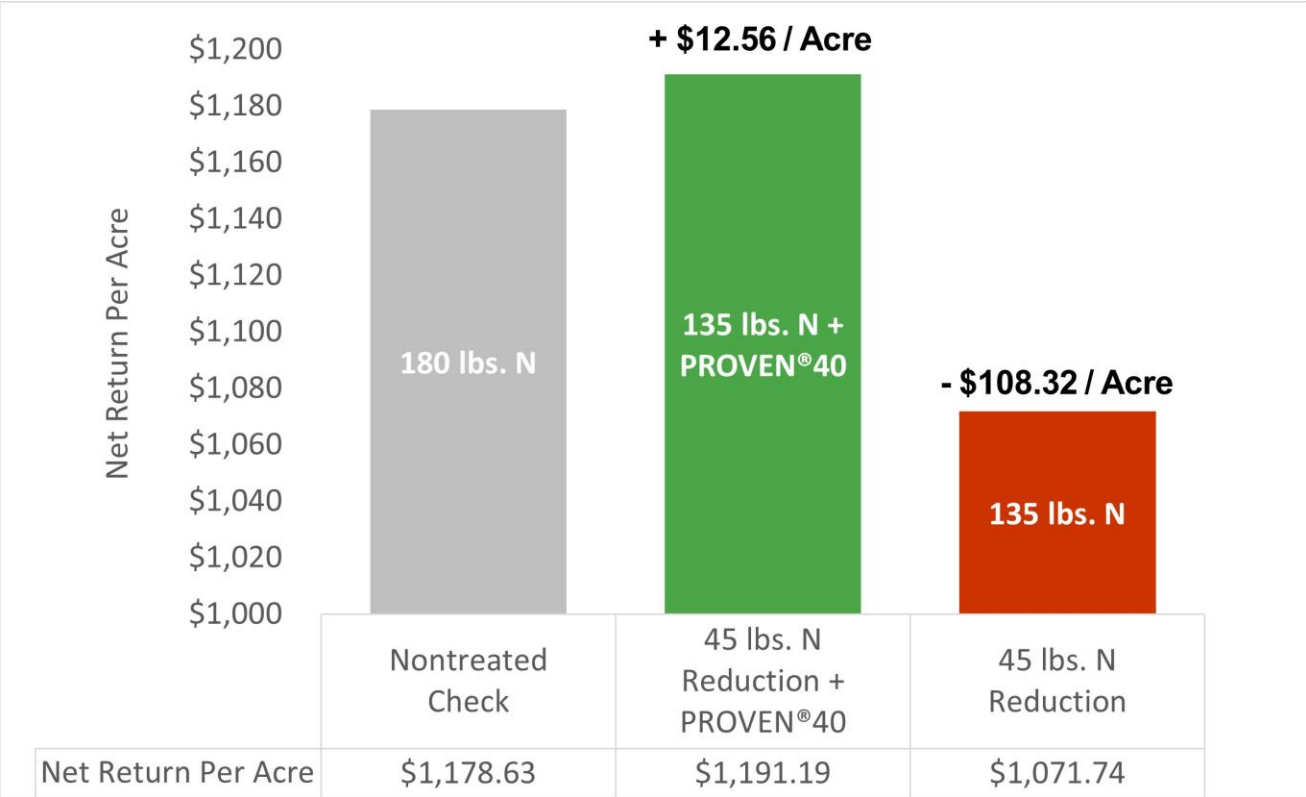
Yield Performance

Results indicate that when PROVEN® 40 was added to the reduced N rate of 135 lbs., a +27.7 bu/A yield advantage was reported versus the 135 lbs. alone.

When PROVEN® 40 was added to the nitrogen reduction treatment (135 lbs.), the product not only replaced the 45 pounds of N but also yielded slightly higher, +0.9 bu/A, than the 100% nitrogen nontreated check (180 lbs.).

This report has been produced by an independent 3rd party consulting firm, 9 North Group, utilizing data collected and processed by Precision Planting.

PROVEN® 40 has consistently demonstrated that N can be reduced by 45 lbs. while increasing yield and revenue.



	Nontreated Check	45 lbs. N Reduction + PROVEN®40	45 lbs. N Reduction
Net Return Per Acre	$1,178.63	$1,191.19	$1,071.74

Return on Investment

To calculate the return on investment, the following assumptions were used:

- Corn Price: $6.00
- UAN32%: $0.78/lb.
- PROVEN® 40 Price: $21/A.

When the 100% nitrogen rate was reduced by 45 lbs. of N and replaced with PROVEN® 40, revenue was increased by +$12.56/A.

This report has been produced by an independent 3rd party consulting firm, 9 North Group, utilizing data collected and processed by Precision Planting.

Academic Abstract Showcase

The following slides represent a series of university findings & formal academic abstracts highlighting the significant advancements and research findings associated with Pivot Bio's PROVEN® 40. These studies showcase its role in enhancing nitrogen fixation, maintaining crop yields, and reducing environmental impacts in corn production agriculture.

Purdue University trial at multiple N rates demonstrates impact at both High and Low N rates, down to a control of 0 added synthetic

2021 - 2022 Pivot Bio PROVEN® 40 OS **Efficacy Trials**
Conducted by: Purdue University

Location
West Lafayette, IN

Trial Year
2021 - 2022

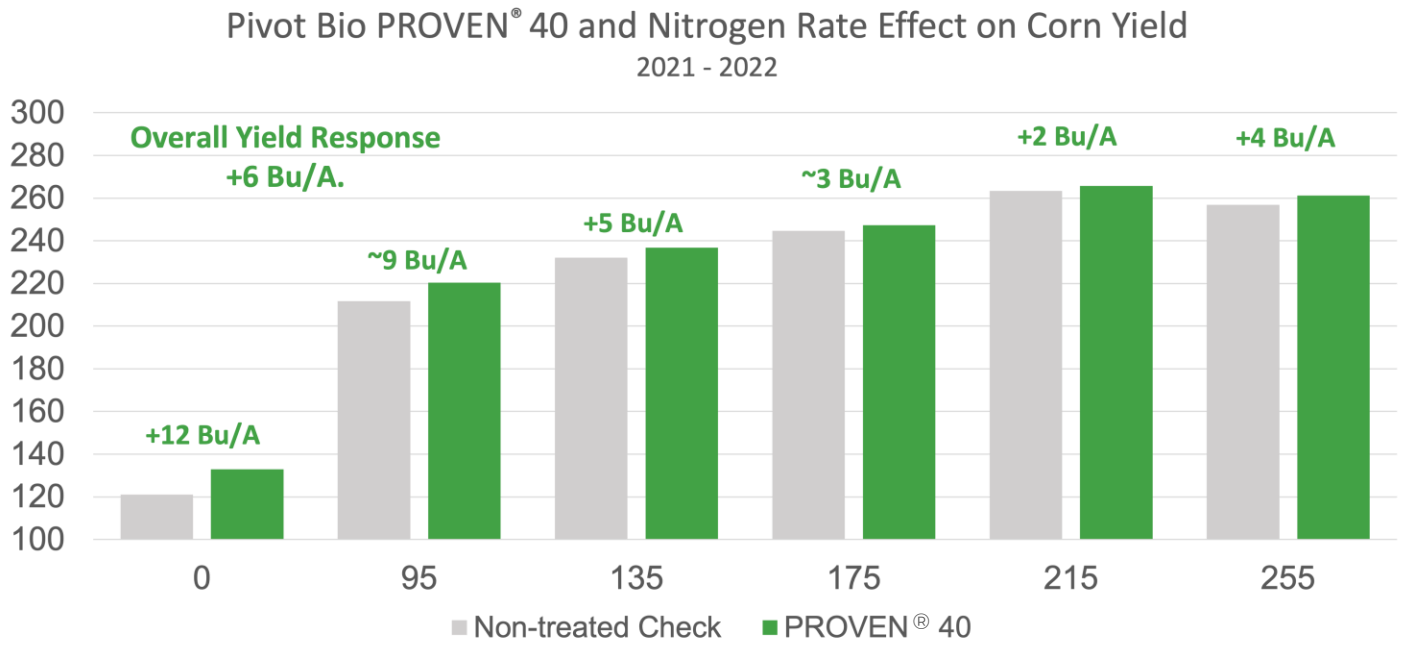
Purdue University

Objective
The objective of this trial was to evaluate the effect of Pivot Bio PROVEN® 40 on yield at various nitrogen rates.

Protocol	This was a replicated large plot trial conducted near West Lafayette, IN at Purdue University ACRE research farm. Pivot Bio PROVEN® 40 was compared to a non-treated check using six different nitrogen rates. Treatments: • Non-treated check • Pivot Bio PROVEN® 40 Nitrogen Rates: • 0 Lbs./A • 95 Lbs./A • 135 Lbs./A • 175 Lbs./A • 215 Lbs./A • 255 Lbs./A
Details	• Soil Type: Silt Loam • Hybrid: P1395AM • Planting Date: April 28 (2021) May 2 (2022) • Plots: 30 x 100 feet. Split plot design with 8 replications. • Seeding Rate: 31,000 seed/A (2021) 34,000 seed/A (2022) • Nitrogen Application: 0-255 Lbs./A UAN coulter applied at V5 Growth stage.

This report has been produced by an independent 3rd party consulting firm, 9 North Group, utilizing data collected and processed by Purdue University.

PROVEN® 40 treated corn plants yielded more bushels per acre compared to the non-treated check, across all nitrogen rates.



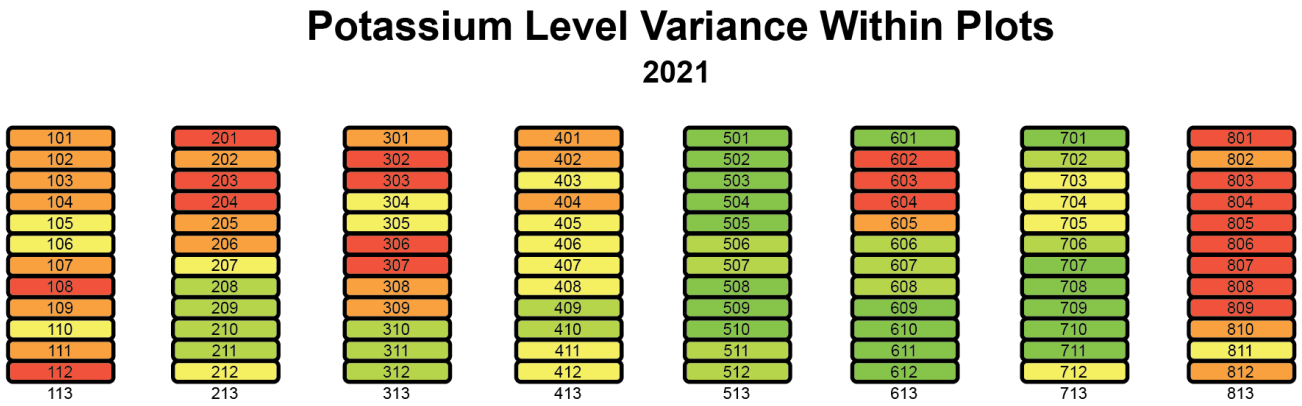
Yield Performance Across Nitrogen Rates

Averaged over two years, corn treated with Pivot Bio PROVEN® 40 had numerically higher yields across all nitrogen rates compared to the non-treated check.

Averaged across nitrogen rates and years, Pivot Bio PROVEN® 40 increased corn yield +6 Bu/A Yield response to Pivot Bio PROVEN® 40 was greater in 2021 than in 2022 (data not presented).

This report has been produced by an independent 3rd party consulting firm, 9 North Group, utilizing data collected and processed by Purdue University.

PROVEN® 40 treated corn plants yielded more bushels per acre compared to the non-treated check, across all nitrogen rates.



Values ranged from 83 to 408 ppm soil test potassium.

Effect of Soil Test Potassium Levels on Response to PROVEN® 40 in 2021		
	Soil Test Potassium Range (ppm)	
	83-134 (Low)	134-408 (high)
Number of Observations (n)	23	25
Soil Test Potassium Mean (ppm)	109	199
Yield Response to PROVEN® 40 (Bu/A)	+4.2	+13.0

Effect of Potassium Levels on Yield Response

2021, corn yield response to PROVEN® 40 was greatly influenced by soil test potassium levels. In plots that ranged from 83 to 134 ppm soil test potassium, the yield response to PROVEN® 40 was +4.2 Bu/A compared to +13.0 Bu/A in plots with potassium levels that ranged from 134 to 408 ppm.

Corn yield response to synthetic nitrogen is often limited by lack of other critical nutrients. These results suggest that response to PROVEN® 40 can also be reduced when nutrients like potassium are not available in adequate quantities.

Full Abstract

Corn Response to Pivot Bio PROVEN 40® Under Variable Soil Potassium Levels and Contrasting Seasonal Precipitation

Garrett Verhagen[1], Dr. Rafael Martinez-Feria[1], Brendan Hanson[2], and Tony Vyn[2]

PURDUE AGRICULTURE | AGRONOMY

[1] Pivot Bio Inc., Berkeley, CA. USA
[2] Purdue University Agronomy Dept., West Lafayette, IN. USA

PIVOT BIO

Objective Evaluate corn response to PROVEN 40® under spatially variable soil K levels in a wet (2021) and dry (2022) season.

Background

- Commercially grown corn (*Zea Mays* L.) hybrids extract large quantities of potassium (K) from the soil during vegetative growth (V6-V14).
- Adequate soil moisture increases the proportion of K in the soil that is plant-available.
- Potassium helps facilitate plant uptake and assimilation of nitrogen (N).
- PROVEN 40® consists of atmospheric N-fixing bacterial strains that colonize corn roots and provide supplemental N to the plant throughout the growing season.

Methodology

A field study was conducted during the 2021 and 2022 growing seasons at the Purdue University Agricultural Center for Research and Education (ACRE) in West Lafayette, Indiana.

Experimental Design

- Split-plot RCBD with eight replications. Six N rates within each block, with a PROVEN 40® and non-treated control (NTC) side-by-side within each N rate. Individual plots were six rows wide (30" row spacing), with a length of 75' in 2021 and 90' in 2022.

Crop Management

- A Pioneer corn hybrid (P1359AM, CRM = 113) was planted in late-April (34,000 plants per ac^{-1}) and two rows per plot were harvested at the end of September. Separate fields were used each year, both historically corn-soybean rotation under conventional tillage.

Nitrogen Management

- Six N rates (0, 95, 135, 175, 215, and 255 lbs. N ac^{-1}) were coulter-injected at V4 using urea ammonium nitrate (UAN; 28-0-0).

PROVEN 40® Application

- Applied in-furrow at plant following label guidelines with distilled water as a carrier.

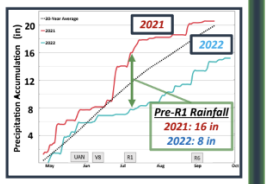
Image 1. Concentrated PROVEN 40® consisting of two separate bacterial strains. Mixed with distilled water prior to application.

Image 2. In-season nitrogen application (2021).

Precipitation

Table 1. (left) and Figure 1. (right) Daily precipitation during the growing season recorded at ACRE. Historical average from 1991 to 2020. Date of N application (UAN), and growth stages (V8, R1, R6) are approximated.

Monthly Precipitation (in)			
Month	2021	2022	30-Yr Avg.
May	6.0	5.8	4.7
June	6.2	1.2	4.9
July	4.1	1.7	4.3
August	2.1	4.5	3.7
Total	18.4	13.2	17.5



Soil Fertility

Soil Fertility 0-20 cm	Year 2021	Year 2022	Unit
Organic Matter	4.1	3.6	%
CEC	19.4	18.1	meq/100g
pH	6.9	6.1	
Buffer pH	7.9	7.7	
Phosphorus	34	31	
Potassium	149	92	
Calcium	2777	2092	
Magnesium	739	586	
Sulfur	11	5	
Sodium	14	15	ppm
Zinc	2.7	1.1	
Manganese	21	27	
Iron	185	130	
Copper	2.8	1.9	
Boron	0.7	0.4	
%K Saturation	1.0	1.4	
%Mg Saturation	15.7	26.8	
%Ca Saturation	35.1	57.6	%
%Na Saturation	0.2	0.4	
%H Saturation	1.2	13.8	

Methods: Organic matter (L.O.I), pH (1:1), minerals (M3)

Image 3a. (left) A 0-8 inch soil core collected via soil probe at V6.

Image 3b. (right) Air drying 15-core composite soil samples prior to shipment for fertility analysis (2022).

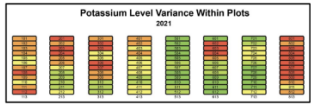


Table 2. (left) The field average of all soil samples collected in 2021 and 2022. Soil was collected from each plot, then air-dried and shipped to Waypoint Analytical (Memphis, TN) for analysis.

Figure 2. (above) The 2021 trial design with soil K level per plot overlayed as a red to green heat map. Values ranged from 83 to 295 ppm in 2021 and from 59 to 131 ppm in 2022 (not shown).

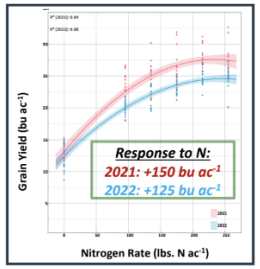
Results

Grain Yield Response to PROVEN 40® and Nitrogen Rate

Treatment	Grain Yield bu ac^{-1} 2021	Grain Yield bu ac^{-1} 2022	Kernel Number Per Ear 2021	Kernel Number Per Ear 2022	Kernel Weight mg kernel^{-1} 2021	Kernel Weight mg kernel^{-1} 2022
Control	233	210	591	500	290	286
PROVEN 40®	242	213	599	504	287	290
Significance	*	ns	ns	ns	ns	ns

Table 3. The effect of PROVEN 40® in-furrow treatment on grain yield and yield components at West Lafayette, IN in 2021 and 2022. Kernel number and weight was collected from 10 consecutive ears per plot at R6 prior to combine harvest. Moisture expressed as 15.5% for grain yield and 0% for kernel weight. Significant differences ($p < 0.05$) indicated with asterisk; "ns" represents non-significant.

Figure 3. (right) Grain yield response to six N rates in 2021 (red) and 2022 (blue). Points represent grain yield of individual plots. Moisture expressed as 15.5%. Polynomial fit quadratic regression lines with r^2 values and confidence intervals ($p < 0.05$) from JMP 17.0.



Soil Potassium Level Associated with Yield Response to PROVEN 40®

Soil Potassium Ranges Class	Melich-3 K (ppm)	Main-Plot Comparisons n 2021	Main-Plot Comparisons n 2022	Grain Yield Response to PROVEN 40® bu ac^{-1} 2021	Grain Yield Response to PROVEN 40® bu ac^{-1} 2022
Very Low	≤ 75	0	4	N/A	5.6
Low	76-100	9	20	4.9	0.8
Medium	101-120	10	11	7.0	-3.5
Sufficient	121-170	16	1	10.1	20.4
High	≥ 171	13	0	11.3	N/A

Table 4. The average soil K of each main plot was categorized by the Tri-State Fertilizer Recommendations for Corn, Soybeans, Wheat, and Alfalfa (Culman et al. 2020). Main plots were assigned to a soil K range by averaging the soil K level in the two corresponding sub-plots. Grain yield response to PROVEN 40® represents the average difference between the yield of PROVEN 40® and NTC sub-plots within each main plot. All 8 replications sampled in 2021, 6 replications sampled in 2022.

Modeled Nitrogen Loss During Wet (2021) and Dry (2022) Growing Seasons

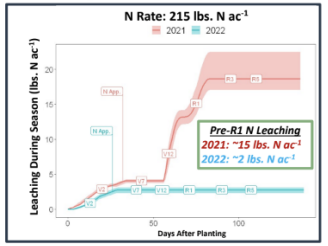


Figure 4. APSIM N loss model estimation of nitrogen losses due to leaching out of the top 24" of the soil profile at the grower standard N rate (215 lbs. N ac^{-1}). Growth stages were derived based on planting date and GDU accumulation. Shaded areas represent the confidence interval ($p < 0.05$).

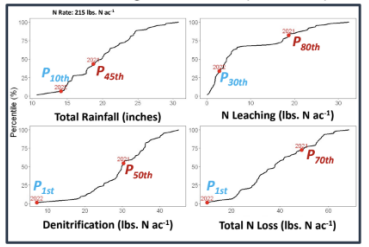


Figure 5. APSIM model estimation of nitrogen losses due to leaching and denitrification at the grower standard N rate (215 lbs. N ac^{-1}) relative to the previous 20 years assuming similar N management. Total seasonal rainfall (planting to harvest) also compared to the 20-year average. P"x"th" represents the percentile for 2021 (red) and 2022 (blue).

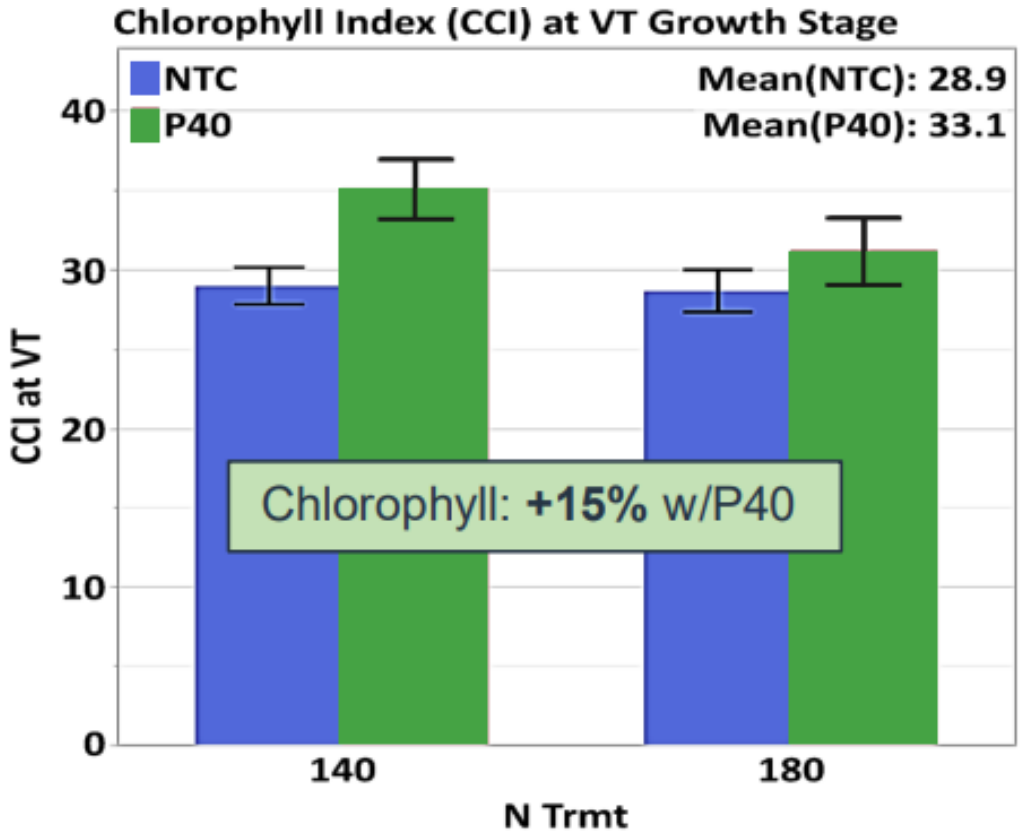
Discussion

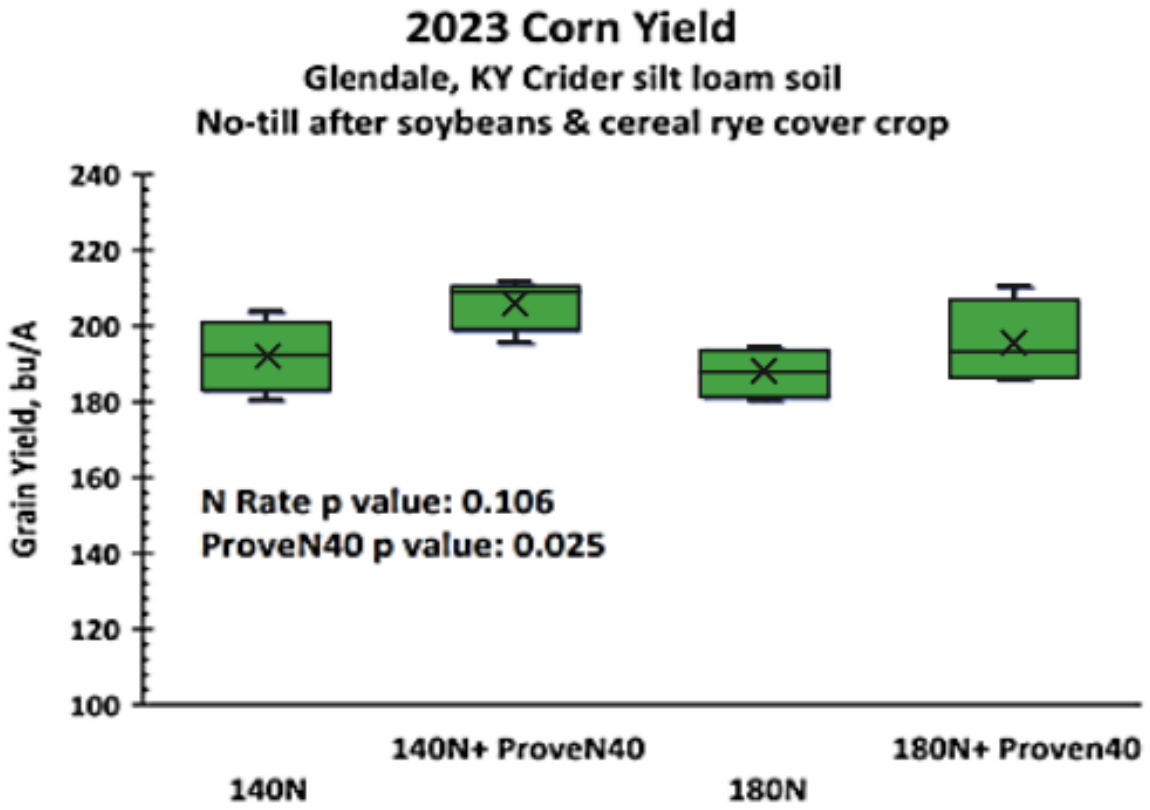
1. **In a wet season (2021), corn response to PROVEN 40® improved as soil K increased from deficient to sufficient ranges (Table 4).**
   - Nutrient balance, N uptake, and N assimilation in the plant benefited from increased plant-available soil K (data not shown), which improved utilization of the supplemental N provided by PROVEN 40®.
2. **In a dry season (2022), corn response to PROVEN 40® was minimal at both low and moderate soil K levels (Table 4), even though the site was N-responsive (Figure 3).**
   - Limited water-availability constrained grain yield and likely decreased plant-available soil K, reducing plant N uptake and the overall N requirement of the crop. Nitrogen losses were also reduced (Figure 5).

University of Kentucky found that replacing up to 40 pounds of synthetic nitrogen with Pivot Bio PROVEN® 40 can increase corn yields while reducing reliance on synthetic fertilizer

Higher yields also demonstrate that applying microbial nitrogen in furrow can help bridge the nitrogen gap that can occur in fields with cover crop rotations.

University of Kentucky



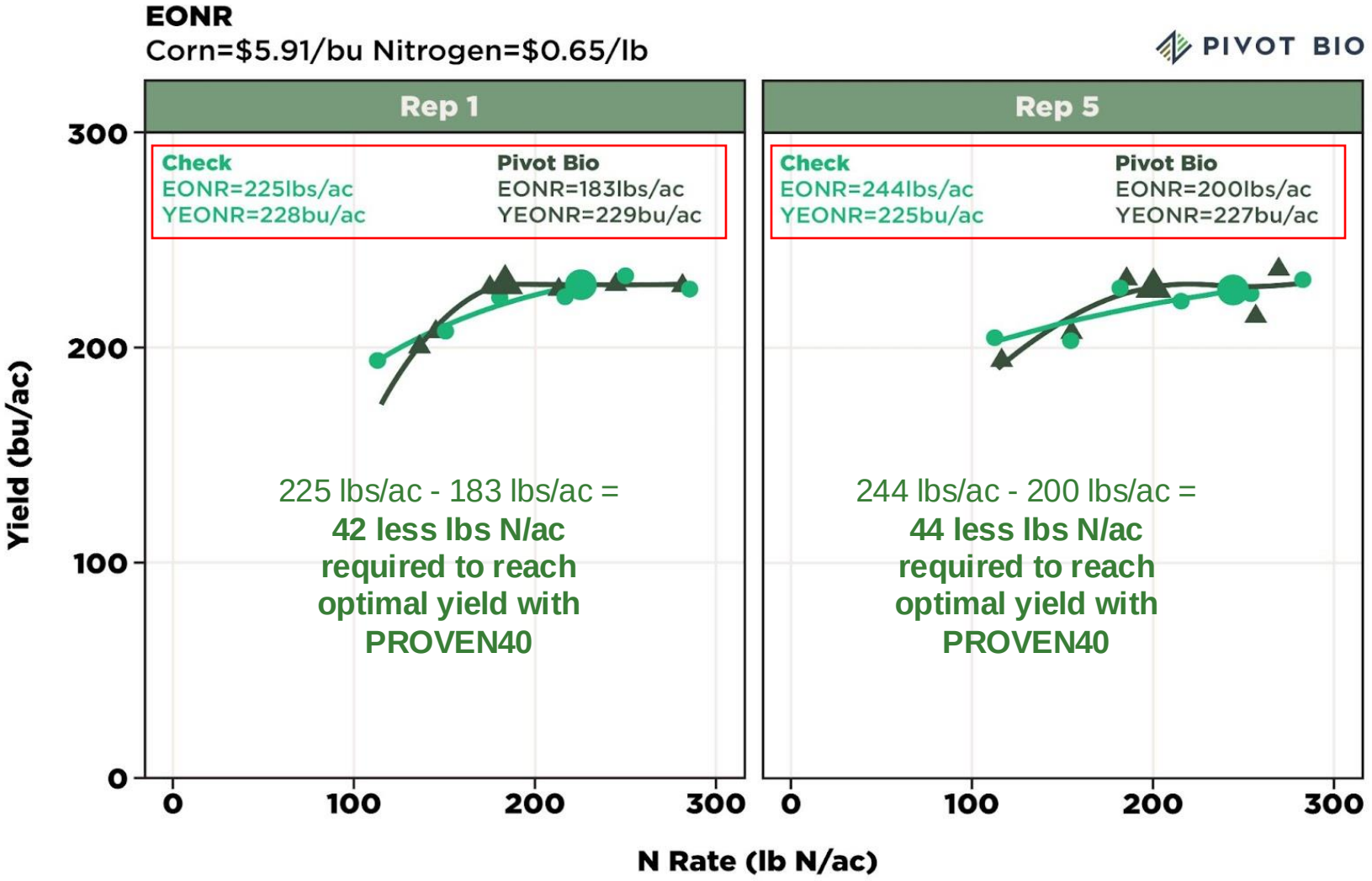


> "Despite limited rainfall during critical growing stages, the in-furrow application of PROVEN 40 stood out as a game-changer on my farm this year."
>
> — Richard Preston, a Kentucky farmer who collaborated with the University of Kentucky Martin-Gatton College of Agriculture.

2023 Study Found 11 Bushel Higher Corn Yield with Pivot Bio's Microbial Nitrogen (Rob Nalley and Chad Lee, PhD)

2023 University of Nebraska Lincoln Study demonstrated that Pivot Bio's microbial nitrogen protects yield potential even in the presence of synthetic N sources, which are less efficient than recognized.

University of Nebraska Lincoln



Results indicate that applying PROVEN40 allowed for a reduction of 42 to 44 pounds of synthetic nitrogen per acre without compromising yield.

"Integrating PROVEN 40 into our N management plan allowed us to significantly lower our synthetic N use while cultivating healthier, high-yielding corn plants. This not only benefits my farm's success but also contributes to environmental conservation, preserving and protecting our land, air, and water for our communities."

- ***Don Baite, a Nebraska farmer who collaborated with University of Nebraska Lincoln on this study.***

The 2023 Penn State study highlights the pivotal role of Pivot Bio PROVEN® 40 in enhancing corn yield. Despite varying nitrogen rates and challenging dry conditions, PROVEN® 40 demonstrated a remarkable 22-bushel per acre yield increase over the standard practice.

Penn State

Results: PROVEN® 40 Performance:

- When compared to the non-treated check, (NTC Full N), PROVEN® 40 had a 3 bushel per acre increase in grain yield (Figure 3).
- When compared to the reduced non-treated (NTC-40 lb. N) both the NTC Full N and the PROVEN® 40-40 lb. N had a yield advantage, 11 bushels and 14 bushels per acre respectively (Figure 3).
- There was no effect on plant population and emergence across all treatments, (data not shown).
- Nitrogen content was not significant when measured across all treatments and nitrogen rates (data not shown).

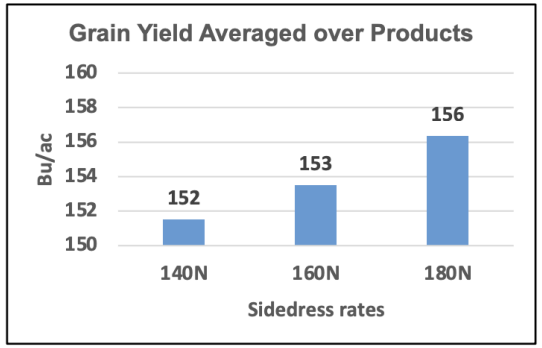


Figure 1. No significant effect of grain yield averaged across nitrogen level with all treatments.

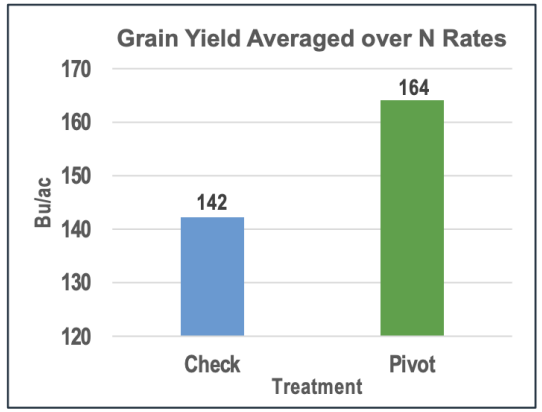


Figure 2. Grain yield averaged across nitrogen level by treatment. In-furrow application of PROVEN® 40 (Pivot), and no in-furrow application, (Check).

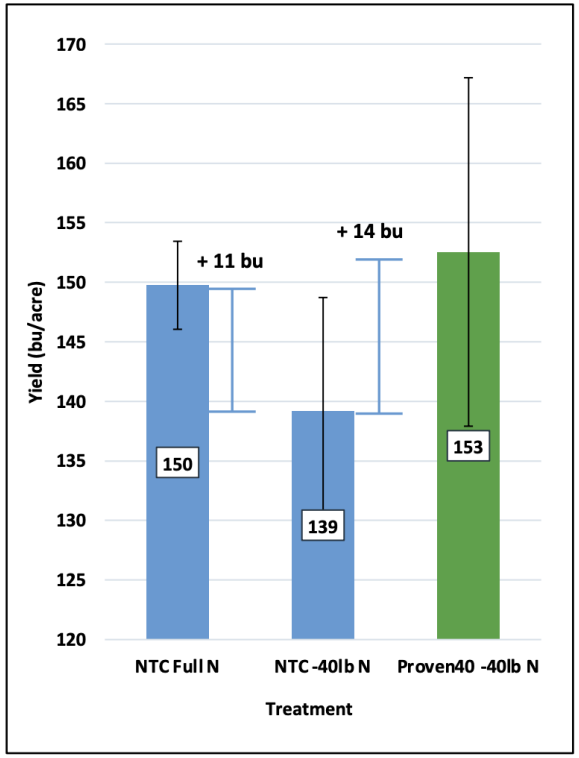


Figure 3. Grain yield by treatment at 180 pounds of nitrogen (NTC Full N), 140 pounds of nitrogen equal to NTC-40 lb. N, and PROVEN® 40-40 lb. N.

Pivot Bio PROVEN® 40 2023 Summary

- In the reduced nitrogen zone, Pivot Bio PROVEN® 40 had a significant yield advantage over the non-treated check.
- PROVEN® 40, with a 40-pound nitrogen reduction, also out-performed the non-treated check at the full nitrogen rate.
- When reviewing the treatments across the nitrogen rates, the nitrogen rate had no significant effect on yield.
- In dry conditions, corn growth can be limited. If corn growth is limited, root exudates are reduced and can slow the production of ammonium for plant uptake.
- When using Pivot Bio PROVEN® 40, it is recommended to plan total nitrogen contribution from all sources to equal the optimum agronomic rate (OAR).

Additional Abstracts

Kansas State University

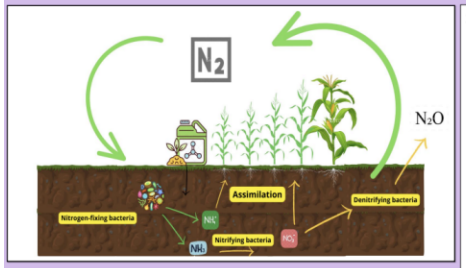
Assessing the impact of root-associated bacteria on corn nitrogen use efficiency

Soil Microbial Agroecology Lab, Kansas State University

Wagner Squizani [1], Irosha Wanithunga [1] and Charles W. Rice [1]

[1]Department of Agronomy, Kansas State University, Manhattan, KS

BACKGROUND



OBJECTIVE

Evaluate the impact of diazotrophic bacterial inoculant on corn cropping system for N uptake, N use efficiency, and net return.

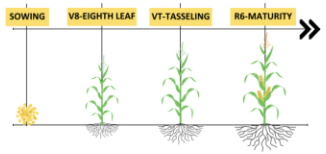
MATERIALS AND METHODS

- **Location:** North Farm corn research plots managed by the Agronomy Kansas State University department.
- **Experimental design:** RCBD.
- ANOVA and linear mixed-effects (lmer) were applied.
- **N management:**

→ N rates: 0, 56, 112 & 168 kg N ha^{-1}

→ Two treatments: with & without Pivot Bio proven®

→ Sowing 2022: June Sowing 2023: April

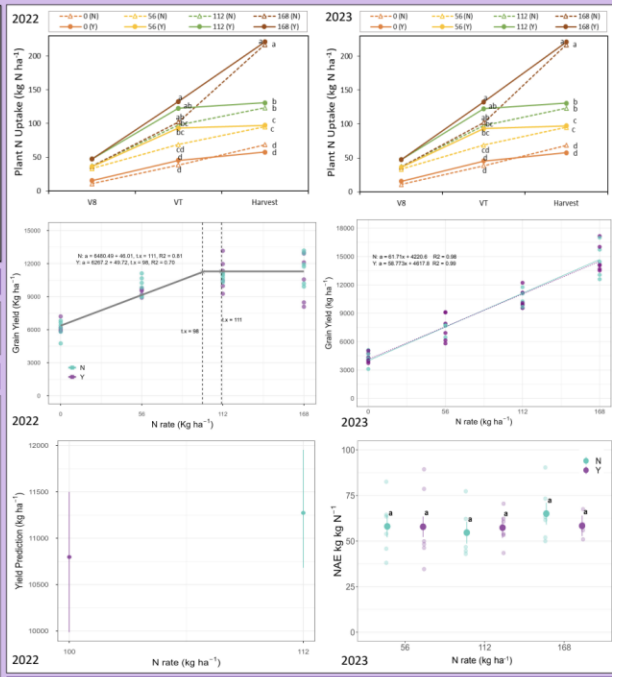


ACKNOWLEDGEMENTS

Soil Microbial Agroecology Lab, Kansas State University

PIVOT BIO PROVEN

RESULTS



CONCLUSIONS

- **N uptake (2022 vs. 2023)**: In 2022, N uptake responded to N rate, with only a significant impact of Proven being observed at the VT stage at the 0 N rate. In contrast, in 2023, Proven exhibited higher N uptake across all stages and N rates, except for the R6 at the 0 N rate, with no statistical significance.
- **Yield (2022 vs. 2023)**: Yield in 2022 and 2023 was responsive to the N rate, with Proven performing better at 112 kg N ha^{-1}, although not statistically significant. In 2022, the optimum N rate with Proven led to similar yields compared to the scenario without Proven, despite the addition of less N. The yield prediction with Proven was slightly lower than without it, but there is still some overlap in the predicted yield.
- **Nitrogen Agronomic Efficiency** Proven appeared to maintain its efficiency even as the N rate increased, with no significant difference compared to the scenario without Proven.

NITROUS OXIDE EMISSIONS IN CORN WITH ASSOCIATIVE NITROGEN-FIXING BACTERIA

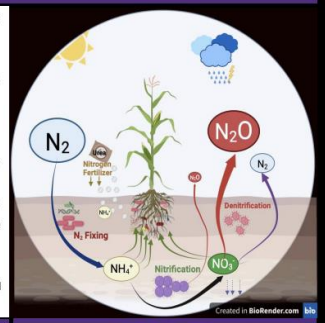
Soil Microbial Agroecology Lab, Kansas State University

Irosha Wanithunga*, **Wagner Squizani**, and **Charles W. Rice**

Department of Agronomy, Kansas State University, Manhattan, KS

Introduction

- Nitrous oxide (N_2O) is a greenhouse gas with a warming potential ~300 times than CO_2
- Stratospheric Ozone depletion gas
- Nitrogen (N) fertilizer used in Agriculture is the primary anthropogenic source of N_2O.
- ~75 % of USA anthropogenic N_2O emission is from the Agriculture.
- A substantial cost is associated with N fertilizer losses due to N_2O emissions.
- Mitigation strategies are needed to reduce N_2O emissions for the future sustainable agriculture production and carbon market.
- Pivot Bio PROVEN™ is a newly developed bio-inoculant product that associates with corn and fixes atmospheric N as NH_4^+



Hypothesis

N_2O emissions reduce with the bioinoculant will reduce the mineral N fertilizer application rate

Objective

Evaluate the N_2O emissions from N fertilizer and Pivot Bio-Proven™ Prototype in corn production

Methodology

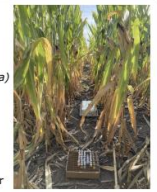
Location:
North Farm corn research plots managed by the Department of Agronomy at Kanas State University (39°12'41.4"N 96°35'42.5" W).
Soil: Kennebec Silt Loam

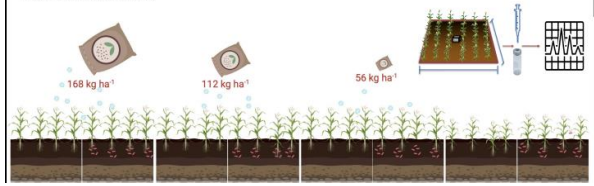
Experiment design:

- Main plot (4)-N rates: **0, 56, 112** & **168** kg N/ha *(**0, 50, 100** & **150** lbs N/ha)*
- Subplot (2)- with & without Pivot bio-Proven prototype bio-inoculant.
- 6 replicates
- Seasonal weather information was recorded on each gas sampling day

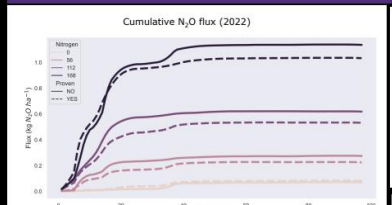
N_2O measurements & analysis:

- Ground base static chamber per plot (0.5 x 0.29 x0.1m)
- Twice a week- planting to VT stage & and, once a week until Harvest.
- Growing season cumulative N_2O emissions were calculated using simple linear interpolating daily fluxes.

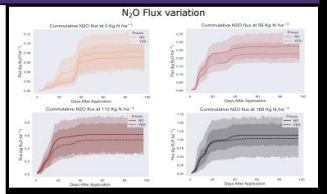


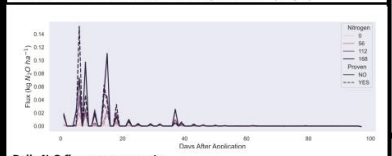


Results and Discussion

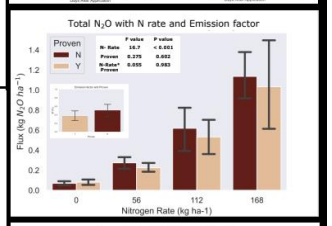


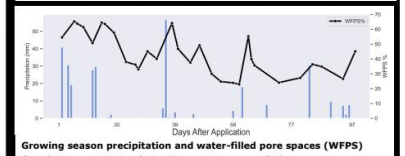
Cumulative N_2O emission
Highest cumulative mean emission=1.14 kg N-N_2O ha^{-1} (168Kg N)
Lowest cumulative mean emission 0.070 kg N-N_2O ha^{-1} (0 Kg N)



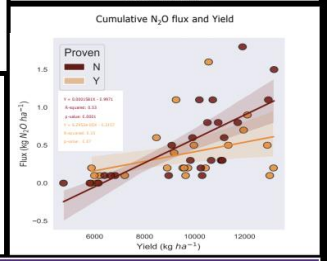


Daily N_2O flux measurements
Highest flux:0.151 kg N-N_2O ha^{-1} day^{-1}
Highest mean emission (first 40 days): 0.032 kg N-N_2O ha^{-1} day^{-1}
Lowest average emission (first 40 days): 0.0017 kg N-N_2O ha^{-1} day^{-1}





Growing season precipitation and water-filled pore spaces (WFPS)
Cumulative precipitation during the growing season: 310 mm
Lower WFPS% detected due to lower moisture levels



Summary

- N_2O emission was higher during the precipitation events only early in the growing season
- Bio-inoculant reduced the cumulative mean emission of all the treatments except 0 N
- N_2O emissions in 2022 were reduced with Pivot Bio-PROVEN™ which were not significantly different.
- Up to ~ 1% of Nitrogen was lost as N_2O.
- Emission Factor <1.00%
- N_2O emission tended to be lower with Proven in the Yield-N_2O flux curve ($p<0.1$)

Acknowledgment PIVOT BIO

University of Georgia

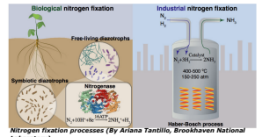
Evaluating Pivot Bio Proven40 Potential to Augment Nitrogen Nutrition in Corn Under Ultisol Soil Conditions in Georgia

Henry Sintim[1], Solomon Amissah[1], Godfred Ankomah[1], Jeffrey Lambert[2], Cameron Prince[2], Roger Black[1], Dan Poston[2]

[1]University of Georgia, United States; [2]Pivot Bio, United States

Study Background

- Several inorganic nitrogen (N) sources of fertilizers are susceptible to losses, which can have adverse impacts on the environment.
- Moreover, the carbon footprint of industrial N fixation is high.
- As the application of N is critical for crop production, especially in highly-weathered soils, the development of more stable and efficient N sources would be valuable.
- Free-living diazotrophs can fix gaseous N into more usable forms by plants, and hence, could potentially augment N nutrition in crops.
- However, the N fixation process is energy-intensive, causing diazotrophs to modulate fixation rates based on soil N levels.



Nitrogen fixation processes (By Ariana Tantillo, Brookhaven National Laboratory)

Objectives

- Evaluate the potential of Pivot Bio Proven40 (PBP40), a commercial product consisting of genetically modified *Klebsiella variicola* and *Kosakonia sacchari*, to augment corn N nutrition.
- Assess different application rates of inorganic N and PBP40 on corn productivity.

Materials & Methods

Location:

- Tifton, GA, USA (31°31'6.6"N,83°32'59.9"W).
- Midville, GA, USA (32°52'39.7"N,82°13'7.3"W).

Experimental Approach-Tifton Site:

- Three N rates (235, 258, and 280 kg ha^{-1}) × three PBP40 rates (0, 1, and 2 L ha^{-1}), except 256 kg ha^{-1} N rate at 0 L ha^{-1} PBP40 rate.
- Established one study in 2022 and two studies in 2023 (early and late planted), constituting three production conditions.
- Treatment plots were 9.7 m long by 5.5 m wide.

Experimental Approach-Midville Site:

- Demonstration replicated strip trial of two PBP40 rates (0 and 1 L ha^{-1}) at 280 kg ha^{-1} N rate.
- Established one study each in 2022 and 2023, constituting two production conditions.
- Average treatment plots were 312 m long by 7.3 m wide in 2022 and 146 m long by 7.3 m wide in 2023.

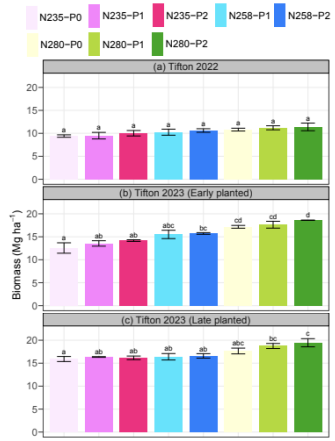
Tifton Results: Grain Yield

- There was a general increase in corn yield with increasing N and PBP40 rates, but the differences were not statistically significant.
- Averaged across the 235 and 280 kg ha^{-1} N rates, as well as over all the production conditions, the 1 and 2 L ha^{-1} PB40 rates increased the grain yield by 0.37 and 0.57 Mg ha^{-1}, respectively.

Treatment	Grain yield (Mg ha^{-1})		
	2022	2023 (Early)	2023 (Late)
N235-P0	14.6±0.6a	15.0±0.4a	12.3±0.3a
N235-P1	14.8±0.8a	15.5±0.1a	12.6±0.1a
N235-P2	15.0±0.7a	15.8±0.3a	12.8±0.3a
N258-P1	15.1±1.0a	15.7±0.1a	13.2±0.1a
N258-P2	15.4±1.2a	15.9±0.2a	13.5±0.3a
N280-P0	14.8±0.9a	15.7±0.2a	13.3±0.1a
N280-P1	15.4±1.0a	16.1±0.2a	13.7±0.1a
N280-P2	15.5±0.8a	16.2±0.3a	13.8±0.2a

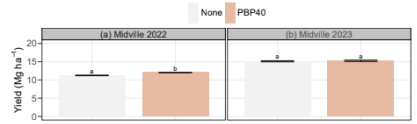
Tifton Results: Biomass at R1/R2

- There were significant effects of N and PBP40 rates on corn biomass under both the early and late planted conditions in 2023 but not in 2022.
- In general, increasing N and PBP40 rates in 2023, led to increased biomass accumulation, with treatment N235-P0 and N280-P2 leading to the lowest and highest biomass, respectively.



Midville Results: Grain Yield

- In 2022, PBP40 application in Midville increased corn yield by 0.79 Mg ha^{-1}, and the difference was statistically significant.
- In 2023, PBP40 application in Midville increased corn yield by 0.14 Mg ha^{-1}, but the difference was not statistically significant.



- At the R2 growth stage of the 2022 experimental site in Midville, orthomosaic map generated from a drone image taken showed stripes in vegetation that mirrored the yield differences between PBP40 applied and non-applied plots.
- Plots without PBP40 application showed light gray-colored stripes, whereas plots with PBP40 application had dark gray-colored stripes.

Conclusion

- The results demonstrate the potential of PBP40 to augment N nutrition in corn, but the performance was not consistent across the production conditions tested.
- Further studies are needed to optimize PBP40 application for enhanced and consistent performance across multiple locations.

Acknowledgement

- Pivot Bio for provision of resources.
- Staff of UGA experiment stations in Tifton and Midville for support with fieldwork.

University of Georgia Henry Sintim (hsintim@uga.edu) Dan Poston (dan@pivotbio.com) Pivot Bio

BARKER Research & Consulting

BARKER
Research and Consulting LLC

Optimal Corn Nitrogen Rate Influenced by the Addition of Pivot Bio PROVEN® 40 OS

Kimmelshue, C.[1], O'Bryan, K.[2], Poston, D.[2], Zuver, K.[2], Kestel, M.[2], Mueller, T.[2], & Christian, E.[2]

1. Pivot Bio Inc., Berkeley CA. USA, 2. Barker Research and Consulting LLC., Ames, IA. USA

PIVOT BIO

Summary

Nitrogen fixing bacteria applied on corn seed prior to planting have shown to decrease plant growth variation, increase plant Nitrogen (N), and optimize yields. Application rate of synthetic N has a varying effect on the performance that is seen from the N fixing bacteria. This research was targeted to determine the effect of PROVEN® 40 OS N fixing microbes *Klebsiella variicola* and *Kosakonia sacchari* across a range of synthetic N application rates in central Iowa. The field study was conducted at a single site across two years, with multiple replications each year. The previous crop in each year was soybean [*Glycine max* (L.) Merr.], and N treatments were applied pre plant in the form of urea ammonium nitrate (UAN 28-0-0) that was knifed in 6-8 inches below the soil surface. N treatments were applied in 40 lbs N acre^{-1} increments from 0 up to 200 lbs N acre^{-1}. PROVEN® 40 OS microbes were applied on-seed at 2.4 fl oz / 80,000 kernels. Proven40os treatments increased grain yield 4.74 Bu acre^{-1} compared to the non-treated control across all treatments in both years. Large variations in rainfall indicated that a greater performance of the N fixing microbes is seen with greater N loss. Applying Proven40os N fixing microbes in combination with 165-175 lbs N acre^{-1} produced similar yields to 202 lbs N acre^{-1} that was documented (INREC) as the average lbs N acre^{-1} application in central Iowa. This study indicates that applying the correct rate of synthetic N in combination with N fixing microbes is essential for farmers to see the highest value when using N fixing microbes.

Material and Methods

This study was conducted near Ames, Iowa, in 2021 and 2022 using a replicated strip plot layout. NDRE, NDVI, leaf firing, and yield measurements were taking to compare PROVEN® 40 OS and NTC at various nitrogen rates across two hybrids each year. PROVEN® 40 OS was applied on seed at 2.4 fl oz / 80,000 kernels.

Nitrogen Rates:

- 2021 - 0, 20, 40, 80, 120, 160 Lbs./A
- 2022 - 0, 40, 80, 120, 160, 200 Lbs./A

Location Details:

- Soil Type: Clarion Loam, Soil pH 6.3, Organic Matter 3.6%, CEC 18.6
- Hybrids:
  - 2021 – P1089AM, DKC59-82RIB
  - 2022 – P1082AM, DKC61-41RIB
- Fertilizer Applications:
  - Surface BDC 150 Lbs./A 0-0-60 + 100 Lbs./A Gypsum
  - 28% UAN banded 6–8 inches deep two weeks prior to planting to establish N treatments

Figure 1. PROVEN® 40 OS product and application method

Figure 2. Drone image of N rate titration response

Results

The 2021 season experienced drought conditions (Figure 3). Drought conditions were severe enough in 2021 that abandonment of the research site was considered for several weeks.

The lack of precipitation in 2021 likely limited the ability of corn plants to fully benefit from the biomass and nutrient uptake advantages established with PROVEN® 40 OS.

Comparatively, growing conditions at this site in 2022 were much more ideal above average rain fall which correlated to greater N loss.

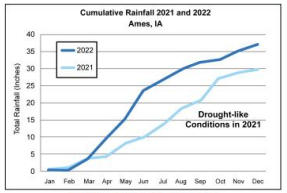


Figure 3. Rainfall in Ames, IA for 2021 and 2022

Results Continued

Figure 4. Images of leaf firing from plots in 2021

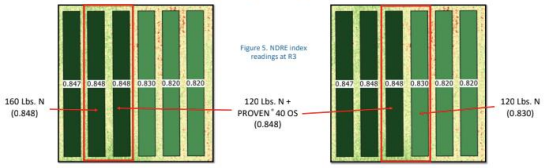


Figure 5. NDRE index readings at R3

In 2021, when drought conditions occurred, maximum corn yield of 180 bu/A was achieved using 120 Lbs./A of nitrogen with Pivot Bio PROVEN® 40 OS. This was similar to the corn yield achieved with 160 Lbs./A of synthetic nitrogen alone. Additionally, the same treatment of using 120 Lbs./A of nitrogen with Pivot Bio PROVEN® 40 OS had equivalent NDRE and NDVI indices, and leaf firing scores at R3 as the 160 Lbs./A of synthetic nitrogen alone treatment.

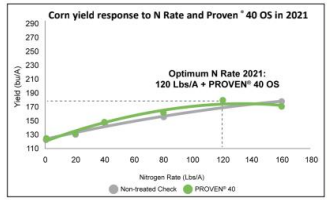


Figure 6. Yield response curve in 2021

In 2022, growing conditions with average rainfall levels, the treatment of 160 Lbs./A nitrogen rate + PROVEN® 40 OS maximized yields at 264 Bu/A, which was 9 Bu/A higher than with the 200 Lbs./A nitrogen rate commonly used by farmers in this region. This was 8.8 Bu/A higher than the treatment of 200 Lbs./A of synthetic nitrogen.

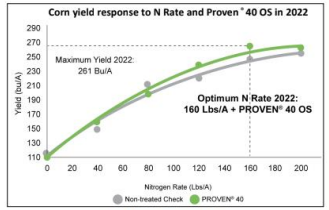


Figure 7. Yield response curve in 2022

Key Takeaways

- Corn yields with PROVEN® 40 OS averaged over years and nitrogen rates were 4.74 Bu/A higher compared to the NTC.
- On the Clarion soils at this site, PROVEN® 40 OS applied in combination with 120 Lbs. of Nitrogen produced yields similar to 160 Lbs. of synthetic nitrogen in 2021 when drought conditions existed.
- In 2022 when ample moisture was available, PROVEN® 40 OS applied with 160 Lbs. of Nitrogen maximized and produced Bu/A equivalent to 200 Lbs. of synthetic nitrogen.
- At this site, applying PROVEN® 40 OS with 165 to 175 Lbs. of nitrogen per acre will likely produce yields similar to the grower average application rate of 202 Lbs./A based on the INREC survey (MRTN ~147 Lbs./A).

Acknowledgements: Thank you to Dan Barker for field work support, and the field technology development team at Pivot Bio for drone imagery analysis suppor

Internal customer nitrogen measurement across millions of acres shows PROVEN® 40 consistently delivers more N

Measurement Methodology

Plant fresh weight and leaf chlorophyll concentrations provide an estimate of how much nitrogen is in the plant

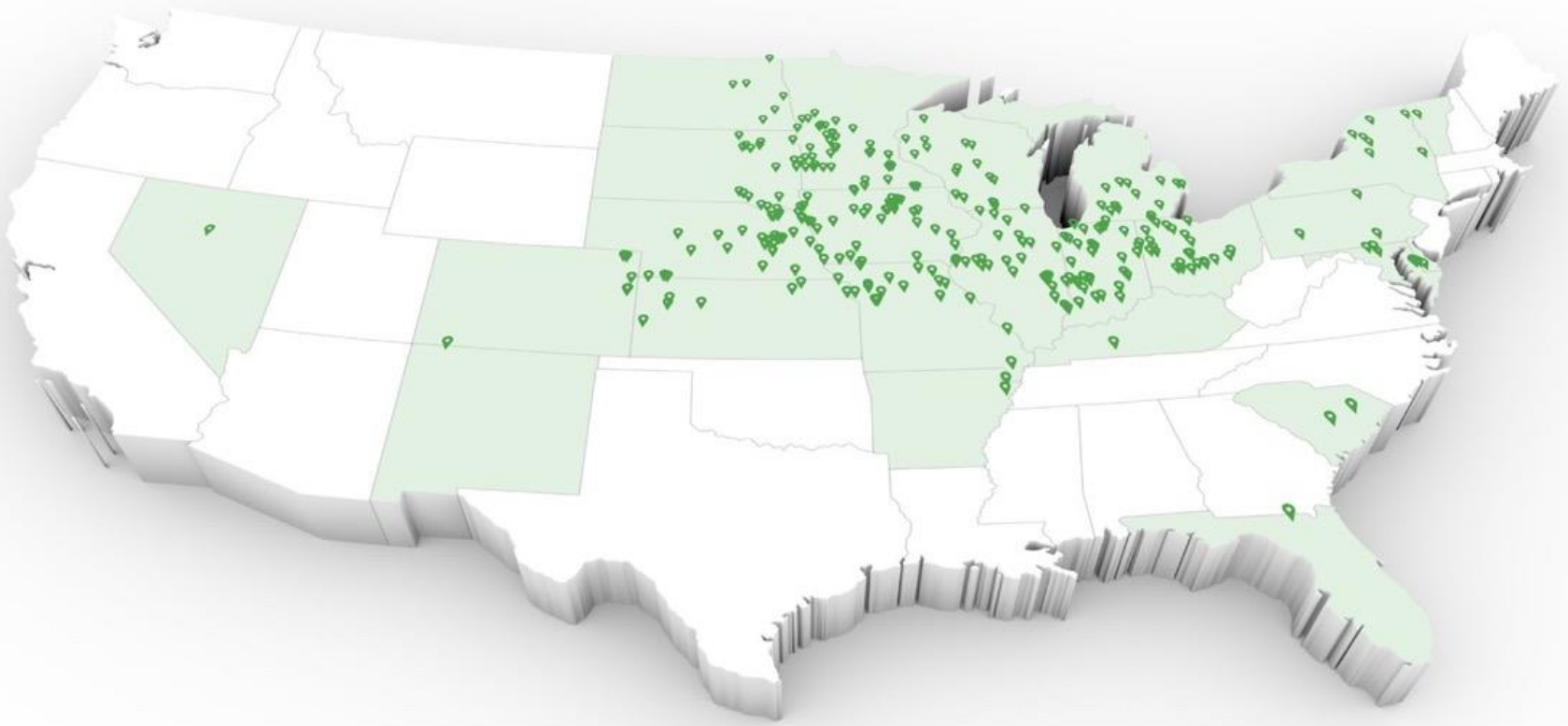
PIVOT BIO PROVEN 40 2021 Growing Season

In 344 farmer demonstration locations from 24 states, with a 35 lbs. reduction of synthetic nitrogen vs. an untreated check, plants treated with Pivot Bio PROVEN® 40 had a 5.5% greater nitrogen uptake.

PLANT NITROGEN UPTAKE

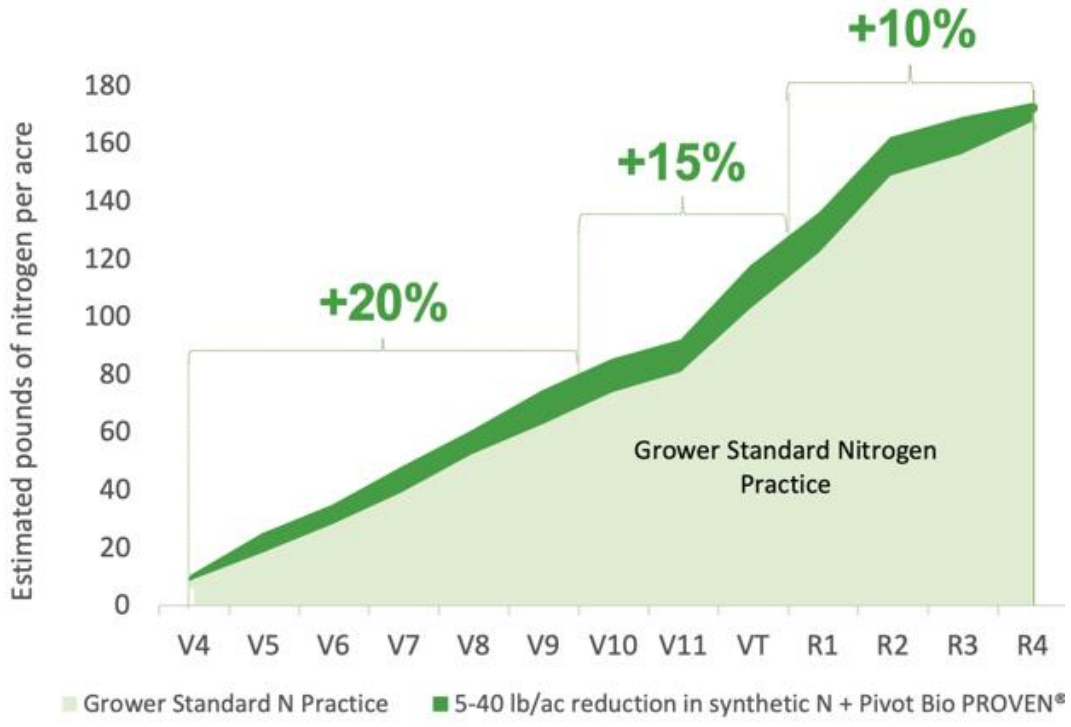
+5.5%

ACROSS GROWTH STAGES



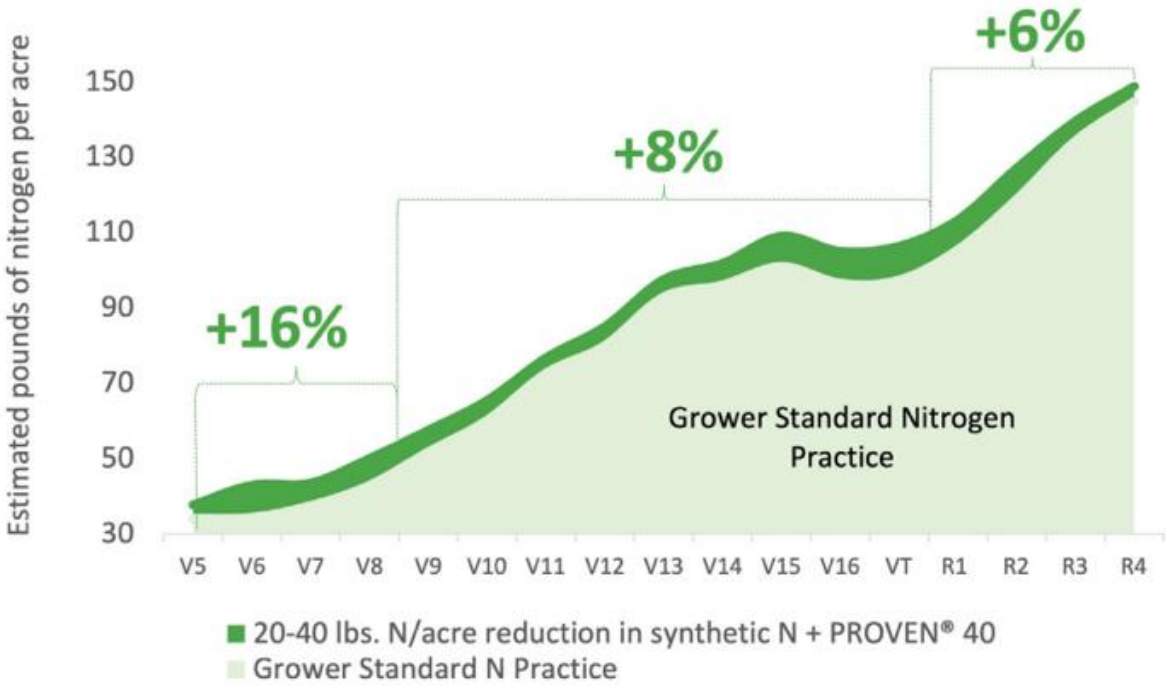
Increased whole plant nitrogen on millions of acres of customer fields

2022



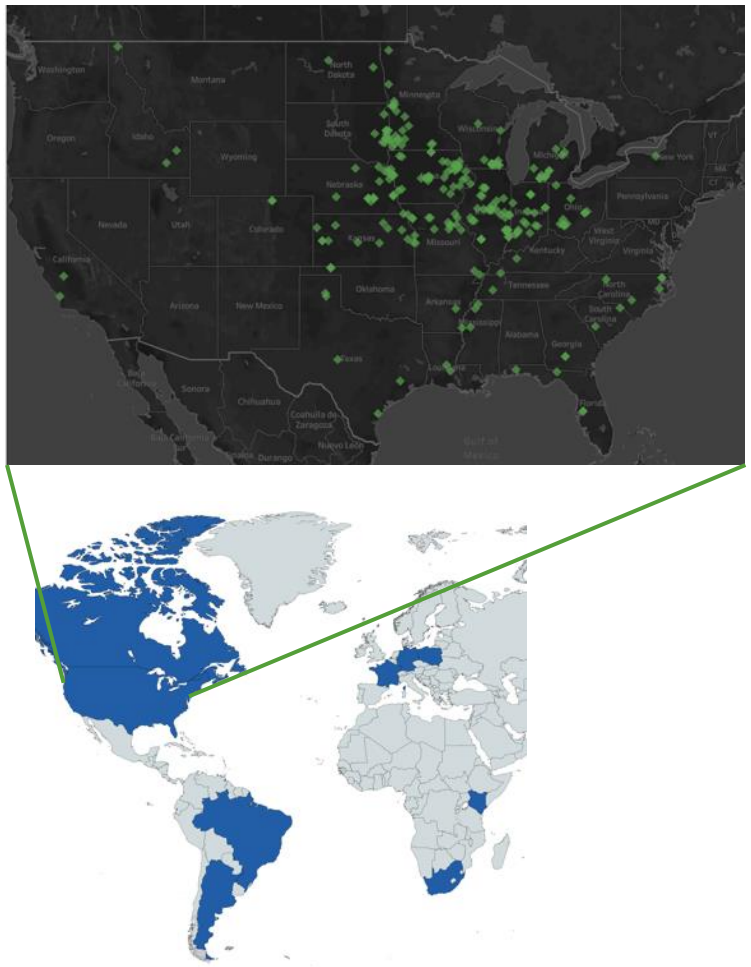
1,260 fields / 34 states

2023

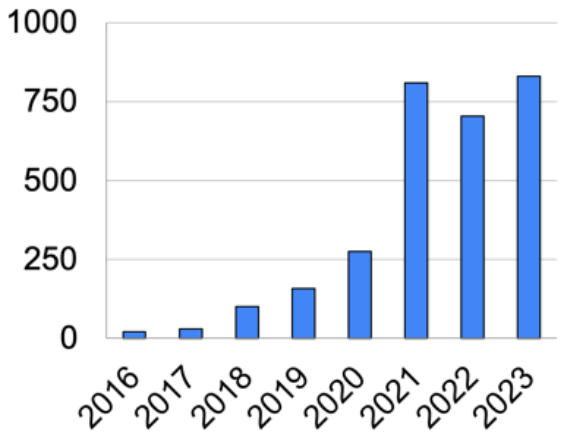


1,500 fields / 32 states

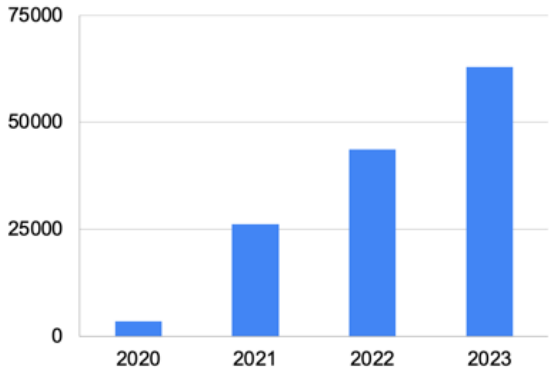
Pivot Bio has built a network for nitrogen science at unprecedented scale



Field trials



Tissue samples



Peer-Reviewed Papers

Publicly available peer-reviewed research papers

- Description of nitrogen fixation in Kosakonia sacchari taken from corn roots: *https://academic.oup.com/jxb/article/71/15/4591/5817768*
- Root-associated bacterium that can fix and supply nitrogen to cereals could offer a sustainable solution for nitrogen management on a shorter timescale: *https://pubmed.ncbi.nlm.nih.gov/31790876/*
- Pivot Bio PROVEN demonstrated as a successful, safe commercial pathway for replacing and reducing synthetic nitrogen in production agriculture: *https://pubs.acs.org/doi/10.1021/acssynbio.1c00049*
- New insights into the mode of action of nitrogen-fixing microbes on corn roots, offering a promising pathway for reducing synthetic nitrogen use: *https://www.researchsquare.com/article/rs-4952488/v1*

More information about our research is available with Pivot Bio's team of agronomists and scientists, providing further insights into the results presented.

Please contact us for a detailed discussion and additional information.

Pivot Bio products have been put to the test in thousands of on-farm, independent third-party and college and university trials.

This scientific research is exciting and undeniably conclusive.

For a complete look at our latest research, please visit Pivot Bio's research library at www.pivotbio.com