SOIL BIOLOGY
TESTING ESSENTIALS

Featuring sampling guidelines, resources for interpreting the Soil Biology Report, and insights from the field

Waypoint ANALYTICAL

TABLE OF CONTENTS

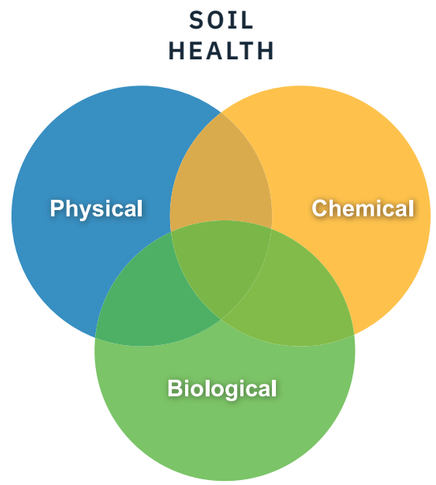
THE SOIL BIOLOGY REPORT

Understanding the microbes living in your soil is crucial to developing a holistic nutritional solution for your field. Soil microbes act as the engine for soil health by cycling nutrients, shaping soil structure, and promoting crop resilience by producing plant hormones. In this way, soil microbes help crops grow and protect them from stresses like drought.

Microbes both store nutrients in their biomass and help to convert decaying residues into nutrients that crop roots can use in a process called mineralization. However, while some soil microbes help crops, other microbes reduce nutrient availability through processes like denitrification, which causes nitrogen loss to the atmosphere. Soils that are more balanced between microbes that cause nutrient loss and conservation can provide greater nutrition to crop plants.

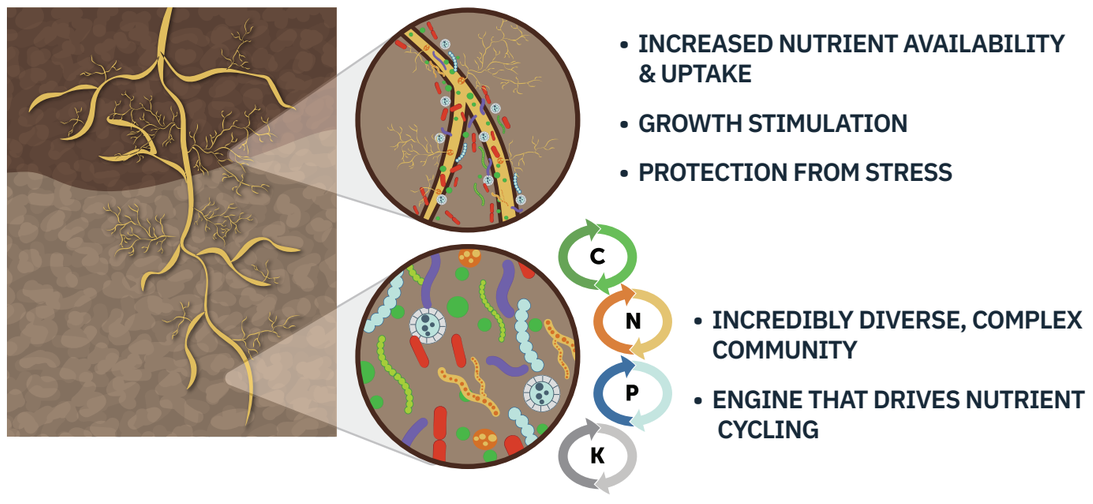
Understanding how well a field's soil microbes can cycle nutrients and how they are balanced between nutrient loss and conservation can help us use fertilizers more efficiently. With enough knowledge, we can promote favorable microbes and mitigate the effects of unfavorable microbes to optimize crop nutrition.

The Soil Biology Report provides the tools needed to identify underlying causes of field variability, validate how products work in a field, and make decisions to maximize soil health. Our approach uniquely focuses on measuring the functional genes microbes use to cycle nitrogen, phosphorus, and potassium to show what microbes are doing in your soil. This approach is more precise, comes at a lower cost, and is designed to fit into your normal soil sampling process.



As of Spring 2024, the Soil Biology Report also includes tests for sulfur-cycling microbial genes and reflects how you prefer available P to be reported (Olsen/Bray/Mehlich). In the coming years, the Soil Biology Report will continue expanding, with plans for new markers in 2025.

This booklet shares insights from the 2023 field season, explains the "why" behind sampling for soil biology, and shares resources around how to sample for soil biology, incorporate soil biology testing into trials, and interpret the Soil Biology Report.



- INCREASED NUTRIENT AVAILABILITY & UPTAKE
- GROWTH STIMULATION
- PROTECTION FROM STRESS
- INCREDIBLY DIVERSE, COMPLEX COMMUNITY
- ENGINE THAT DRIVES NUTRIENT CYCLING

TESTIMONIALS

REESE MARTIN, LOVELAND PRODUCTS

“The way I see soil health... it’s a large factor in our agricultural production. I think it’s an area that we overlook.”

“We have an opportunity now with Waypoint not only for our tissue, our leaf, our soil sampling, now we can actually look and see and quantify what impact we’re having on our microbial community.”

“We have to protect the soil, the soil health, in order to continue to produce in agriculture, whether it’s a tree crop, a row crop, or a specialty crop.”

DAVID DOONAN, NUTRIEN AG SOLUTIONS

“It started with a goal to create a best-in-class customer experience, with an effort to help our growers reach their operational goals [and] to grow our LPI business by providing sound agronomic recommendations that are data driven and backed by science.”

RODNEY RATZLAFF, LOVELAND PRODUCTS

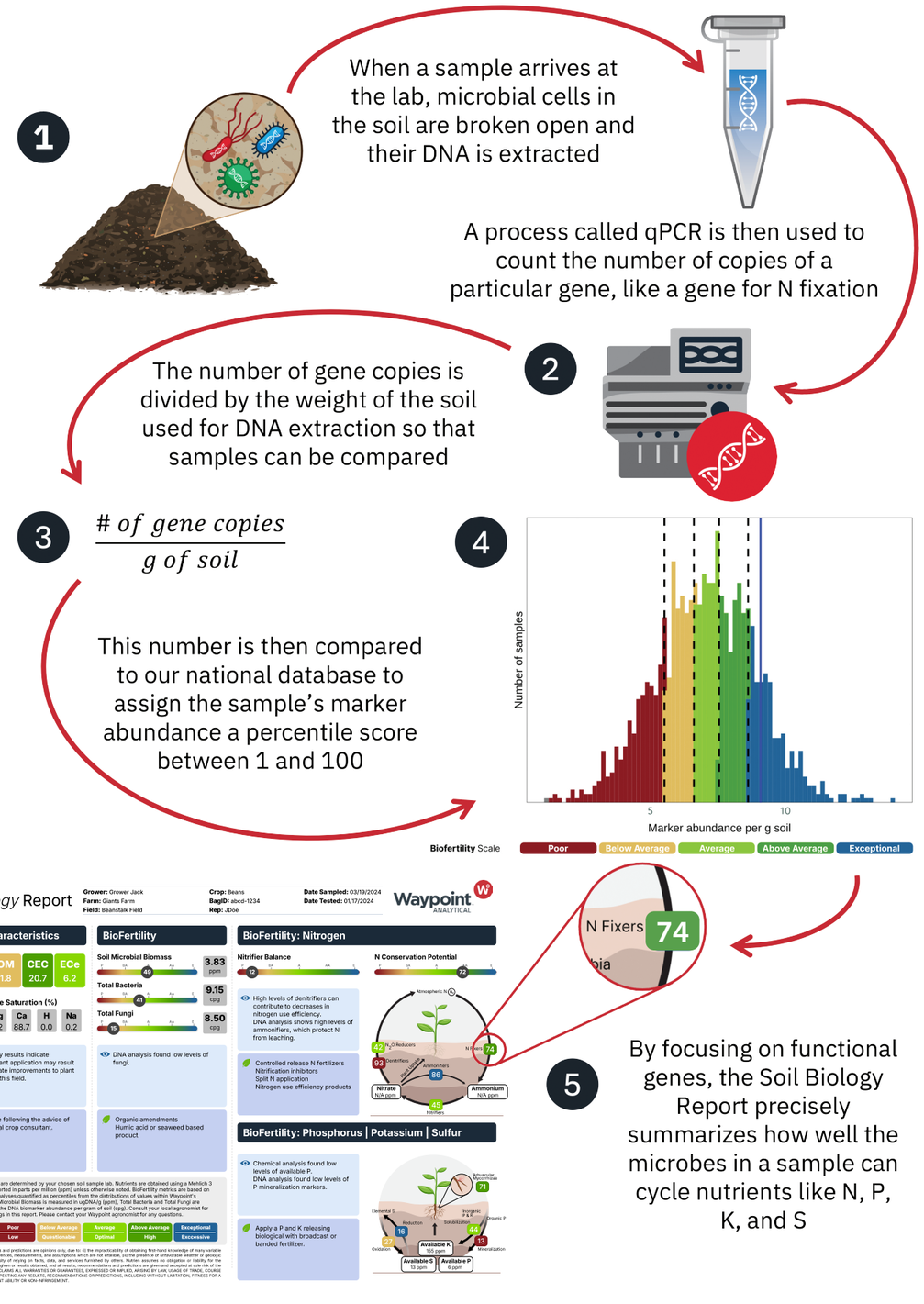
“We know we have a basic soil report, but that only gives us so much information. Soil biome takes that soil report to the next level with being able to understand specific microbiology that’s lending a hand toward NPK and even micronutrient use efficiency.”

“What excites me about this is that we’re dialing in specific recommendations per field and being able to give a lot more accurate recommendations from crop nutrition and building a more holistic crop nutrition program.”

SHANE VAN FLEET, NUTRIEN AG SOLUTIONS

“It has really shown me that we have the technology available to get the max efficacy out of products, and refine product application while improving soil health... We now have the ability to place the right products on the right farms.”

HOW DOES SOIL BIOLOGY TESTING WORK?



HOW TO SAMPLE FOR SOIL BIOLOGY

Waypoint's soil biology test is designed to fit into your normal soil sampling process and requires no special equipment.

Two common reasons to test soil biology are (1) **to diagnose potential issues in a field** and (2) **to evaluate how a product or program changes a field's soil biology**. Consider the following if you are interested in using soil biology testing for either reason.

HOW MANY SAMPLES SHOULD I TAKE?

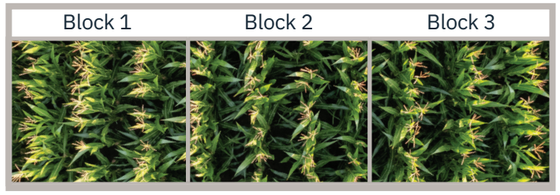
If you want to use soil biology testing to better understand and address issues in your field, we recommend taking 2–3 samples from areas that represent, for example, low-, average-, and high-productivity parts of a field.

If you are testing soil biology to trial products or practices, we recommend deciding between either (1) a simpler demo approach or (2) a more intensive trial setup.

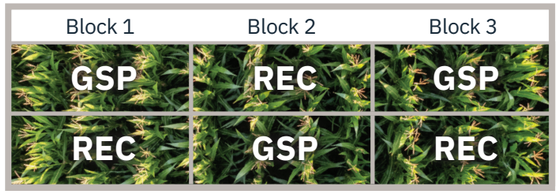
For a demo approach, we recommend sampling both the grower standard and each treatment over at least two timepoints: before and after product application (i.e., 4 samples minimum). We have generally seen the clearest difference between treated and untreated samples at 2–6 weeks after product application. There could be reason to sample outside of that time window, so feel free to contact Waypoint with questions about sampling.

If you are interested in conducting a more intensive trial, we still recommend sampling over at least one pre-treatment and one post-treatment timepoint, but you may also consider sampling at additional post-treatment timepoints (e.g., at 0, 3, and 6 weeks after application) to better understand when products yield the strongest effects on soil biology.

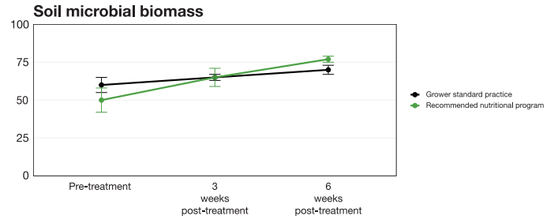
A more intensive trialing approach will most importantly involve replication. To create a randomized complete block design, we recommend first dividing your field into as many "blocks" of equal size as there are replicates. Three replicates is generally considered a minimum.



Next, divide each block by the number of treatments and randomly assign treatments to plots within the block. In the example below, the blocks have been split in half for the two treatments. Assigning treatments randomly rather than placing them on, say, the north and south sides of a field, will help minimize the chances that field variability (like a more acidic south half of the field) affects your results.



In the figure above, one composite sample (i.e., one bag with 8–10 cores), would be taken from each of the six squares at each timepoint. If you took this approach and decided to sample over three timepoints, here's what those results might look like.



By taking the average of all three replicates from each treatment at each timepoint, we can see that the effects of the recommended treatment on microbial biomass were strongest at 6 weeks after application.

HOW SHOULD I SAMPLE?

1. Collect composite samples from the top 6 inches of soil with 8-10 cores per sample.
   - If you will be sampling over multiple timepoints, we recommend flagging each spot that composite samples are taken from in order to most accurately compare samples between timepoints.
   - We recommend collecting soil either close to crop roots, where microbes are most abundant, or within the zone of application, where product effects are expected to be strongest.
2. Fill out the Waypoint Submission Form - example on the next page.
3. Ship samples to the Waypoint Analytical facility you typically use, or directly to Waypoint, IL (2902 Farber Dr., Champaign IL 61822).
   - DNA is fragile. Store soil samples at room temperature or cooler and make sure to ship soil samples within 3–4 days of sampling. Avoiding shipping samples on Fridays.
   - Like traditional soil samples, soil biology samples can be shipped in paper sampling bags. Soil biology testing will include an S3M test.

HOW TO SAMPLE FOR SOIL BIOLOGY *(CON'D)*

WHAT PRODUCTS CAN I TRIAL WITH SOIL BIOLOGY TESTING?

Soil biology testing works best for trialing soil-applied products. We do not recommend soil biology testing to trial foliar-applied products. Application methods that involve low product concentrations, such as broadcasting, may also produce subtler effects on soil biology.

Waypoint ANALYTICAL
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SOIL SAMPLE INFORMATION SHEET

CUSTOMER INFORMATION				GROWER INFORMATION			
Jane Doe				Research Farm			
123 Lettuce Way				123 Lettuce Way			
Farmtown, MA 22222				Send Report to e-mail address		research@researchfarms.com	
Account #	12345	Grower ID	Research Farm	Farm ID	Location 5	Field ID	Trial 111

Please check samples in column provided if Herbicide or Nematode analysis requested. If Herbicide, please indicate name of Herbicide in Add'l Info box below.

Lab Number (Lab Use Only)	Sample ID (6 chars. max)	S2M - Specify Add'l Tests: S1M	B	Cu	Fe	Mn	Na	S	Zn	S3M	Soluble Salts	Texture	NO3-N	Additional Tests	Intended Crop Code	Intended Crop Yield	Alternate Crop Code	Alternate Crop Yield	Previous Crop	Herbicide	Nematode
	Ctrl 1									X				Biome							
	Ctrl 2									X				Biome							
	Ctrl 3									X				Biome							
	Trt 1									X				Biome							
	Trt 2									X				Biome							
	Trt 3									X				Biome							

S1M - Organic Matter, Phosphorous, Potassium, Calcium, Magnesium, pH, Buffer pH
S2M - S1M plus any two of the following: Sodium, Sulfate-Sulfur, Boron, Zinc, Manganese, Iron, Copper. Each additional test (above two) cost $2.00.
S3M - S1M plus all of the following: Sodium, Sulfate-Sulfur, Boron, Zinc, Manganese, Iron, Copper.

CROP CODES TO BE USED IF FERTILIZER RECOMMENDATIONS ARE REQUESTED

If the crop for which you would like recommendations is not listed, write the crop name in the crop code boxes.

FIELD CROPS
1. Barley
5. Canola
10. Corn
11. Corn/Soybeans Rotation
12. Corn - No Till
13. Corn Silage
20. Cotton
21. Cotton - No Till
25. Grain Sorghum
30. Oats
32. Peanuts
34. Popcorn
35. Rapeseed
36. Rice
39. Rye
45. Soybeans
46. Soybeans - No Till
51. Sugarcane - Plant
52. Sugarcane - Stubble
62. Tobacco - Burley
63. Tobacco - Dark
64. Tobacco - Flue Cured
75. Wheat
78. Wheat Silage/Corn Silage
92. Wheat/Beans Double Crop

FORAGE CROPS
101. Alfalfa Hay
103. Alfalfa/Cool Season Grass Hay
106. Alfalfa/Warm Season Grass Hay
116. Bahiagrass Hay
117. Bahiagrass Pasture
121. Common Bermuda Hay
122. Common Bermuda Pasture
123. Common Bermuda/Legume Hay
124. Common Bermuda/Legume Pasture
161. Coastal Bermuda Hay
162. Coastal Bermuda Pasture
172. Cool Season Grass Pasture
173. Cool Season Grass Hay
181. Fescue Hay
182. Fescue Pasture
183. Fescue/Legume Hay
184. Fescue/Legume Pasture
237. Ryegrass

INDICATE TYPE OF GRASS AND/OR LEGUME
297. OTHER HAY
298. OTHER PASTURE
299. CRP

VEGETABLE CROPS
307. Beans - Lima
309. Beans - Snap
320. Cabbage
322. Cantaloupe
330. Cucumbers
340. Garden
369. Peppers
381. Spinach
382. Squash
383. Sweet Corn
384. Sweet Potato(ton)
391. Sweet Potato(bu)
385. Tomatoes
398. Watermelons

FRUIT & NUT CROPS
400. Apples
410. Blueberries
420. Citrus
430. Grapes
470. Peaches
475. Pecans
490. Strawberries

TURFGRASS
512. Bahiagrass Lawn
513. Bahiagrass Sod Production
517. Bentgrass Green
521. Bermudagrass Athletic Field
522. Bermudagrass Fairway
523. Bermudagrass Green
524. Bermudagrass Lawn
525. Bermudagrass Sod Production
526. Bermudagrass Tee
533. Bluegrass Lawn
534. Bluegrass Sod Production
546. Centipede Lawn
547. Centipede Sod Production
561. Fescue Athletic Field
563. Fescue Lawn
564. Fescue Sod Production
576. St. Augustine Lawn
577. St. Augustine Sod Production
583. Zoysiagrass Lawn
584. Zoysiagrass Sod Production

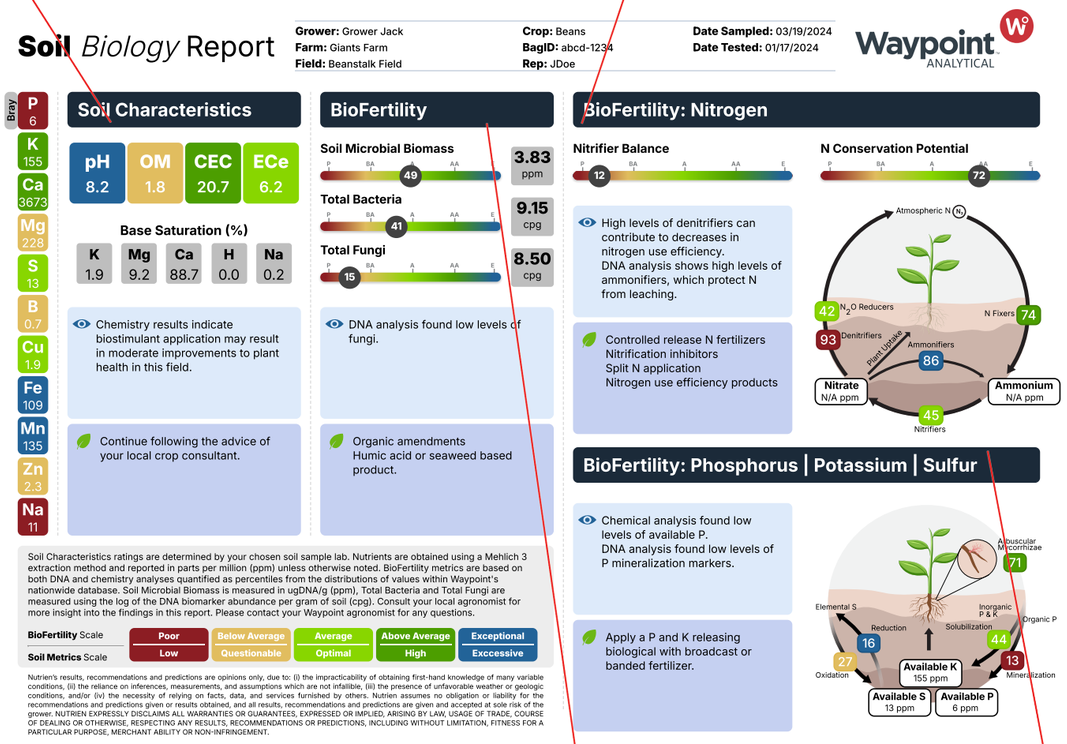
Additional Tests or Other Information

Submittal of information sheet to Waypoint Analytical, Inc. is acceptance of our terms and conditions. All prices are subject to change without notice.
Additional fees may be charged to client if sample requires additional preparation procedures.

UNDERSTANDING THE REPORT

SOIL CHARACTERISTICS
These are just our traditional soil test results from a Mehlich 3 extraction. These give us some baseline information about nutrient availability and our general soil characteristics. We can use these to help us interpret our biological results within the context of our specific soil environment.

BIOFERTILITY: N
These are the biofertility metrics that tell us about the N cycling organisms present in our soil and how those may impact N loss in general. This can help guide our nitrogen management decisions.



BIOFERTILITY
In general, this tells us the capacity of our soil to perform activities like decomposing residues, cycling nutrients, impacting soil C, and more! This helps give us a general indicator about how fertile our soil environment is and how much horsepower we have underground to cycle nutrients for our growing crops.

BIOFERTILITY: P, K & S
These are the biofertility metrics that inform us how inclined our soil is to cycle P, K, and S into plant-available forms for us. This info can be used to help guide our fertility and technology recommendations.

UNDERSTANDING THE REPORT *(CON'D)*

OVERALL BIOFERTILITY

Biology Metric	What it measures	Functions
Total Microbial Biomass	Total DNA content of soil	• Source of crop-available nutrients • Nutrient mineralization • Residue decomposition • Shape soil structure
Total Bacteria	General abundance of soil bacteria	• Decomposition of crop residues and fungi • Nutrient, carbon cycling • Soil structure: microaggregate formation • Higher carbon turnover
Total Fungi	General abundance of soil fungi	• Residue decomposition • Nutrient cycling • Soil structure: macroaggregate formation • Higher efficiency carbon storage • Connect distant resources for crops and bacteria

BIOFERTILITY: NITROGEN (N)

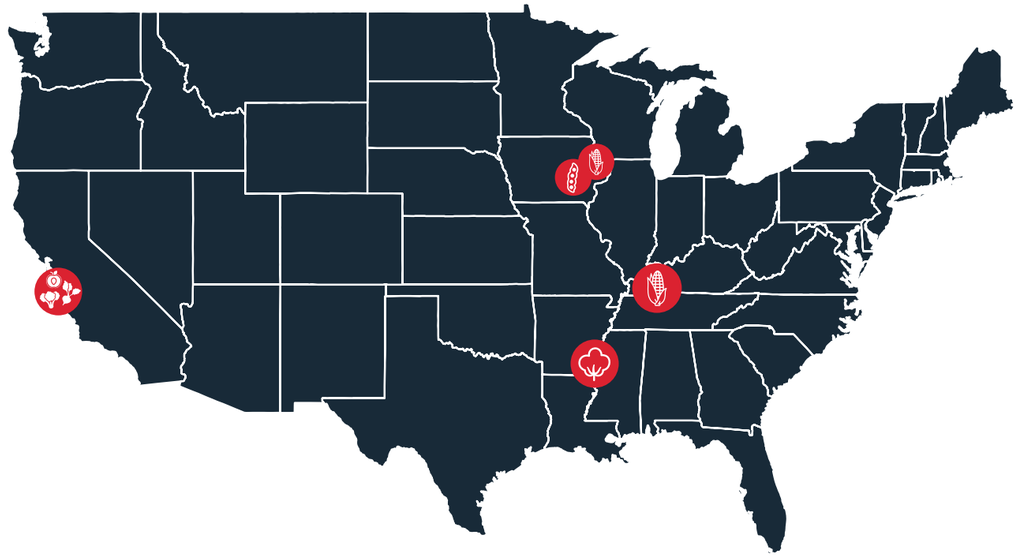
Biology Metric	What it measures	Functions
Total N Fixers	Native soil bacteria, both "free-living" and symbiotic N fixers, that convert atmospheric N to ammonia N	• Conversion of atmospheric N to ammonia N
Bradyrhizobia	Native soil B. japonicum that nodulate soybean and fix atmospheric N to ammonia N	• Conversion of atmospheric N to ammonia N for soybean only
Nitrifiers	Bacteria and related organisms that convert ammonia N to nitrate N	• Conversion of ammonia N to nitrate N • Necessary for optimal plant uptake, but can contribute to leaching under high moisture conditions or in sandier soils • Produce nitrous oxide greenhouse gas
Ammonifiers	Bacteria that convert nitrate N to ammonia N	• Conversion of nitrate N to ammonia N • Can reduce N losses to leaching by converting to ammonia form
Denitrifiers	Bacteria that convert nitrate N to atmospheric N	• Conversion of nitrate N to atmospheric N • Cause significant N losses especially under wet, water-logged conditions • Produce nitrous oxide greenhouse gas
N_2O Reducers	Bacteria that convert nitrous oxide N to atmospheric N	• Mitigate greenhouse gas emissions by reducing nitrous oxide produced during denitrification to atmospheric N
Nitrifier Balance	Metric of nitrifying community balance	• Describes balance between ammonifier and nitrifier populations • Higher levels may contribute to conservation of ammonia N under conditions with potential for leaching • Lower levels may contribute to more available nitrate
N Conservation Potential	Metric of overall community balance	• Describes nitrogen cycling community balance towards loss or conservation • Lower values correspond to increased potential for N losses

UNDERSTANDING THE REPORT *(CON'D)*

BIOFERTILITY: PHOSPHORUS (P), POTASSIUM (K), AND SULFUR (S)		
Biology Metric	What it measures	Functions
Mycorrhizal Fungi	Abundance of soil mycorrhizal fungi	• Important symbiotic partners of most crops (excluding the mustard family—crops like kale, broccoli, brussels sprouts, etc.) • Interact directly with crop roots to provide P, water, and other mineral nutrients to crops in exchange for plant sugars
P Mineralization	Abundance of bacteria that mineralize organic forms of phosphorus	• Mineralize P by breaking down organic P forms such as proteins, DNA, phosphate sugars, and phytate
P and K Solubilization	Abundance of bacteria that solubilize phosphorus and potassium	• Production of organic acids that dissolve insoluble forms of P and K
Sulfur Oxidation	Abundance of bacteria that oxidize elemental S, producing sulfate	• Conversion of elemental S to sulfate, the plant-available form of S
Sulfur Reduction	Abundance of bacteria that reduce sulfite, producing sulfide	• Conversion of sulfite to sulfide • Cause S losses to the atmosphere (in the form of hydrogen sulfide) or insoluble metal sulfides • Favored by waterlogged conditions

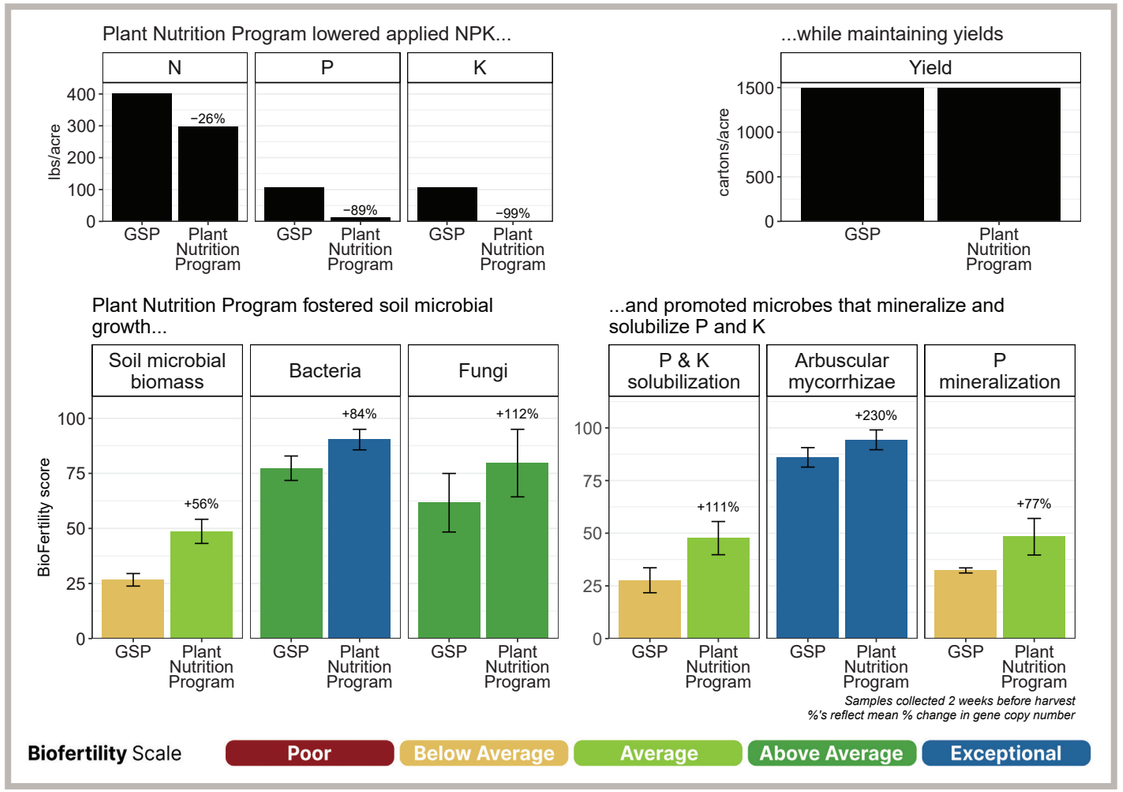
SOIL BIOLOGY CASE STUDIES

TABLE OF CASE STUDIES				
Location	Product	App. Method	Crop	Page
California Central Valley	Plant Nutrition	Irrigation	Celery	10
Iowa	None	None	Corn/Soy	11
Nutrien Ag Solutions Innovation Farm - Kentucky	Plant Nutrition	None	Corn	12
Nutrien Ag Solutions Innovation Farm - Mississippi	None	None	Cotton	13



CALIFORNIA CENTRAL VALLEY

PLANT NUTRITION PROGRAM TO MAXIMIZE YIELD AND BIOFERTILITY AND MINIMIZE APPLIED N, P, AND K AT A CENTRAL CALIFORNIA CELERY FARM



BACKGROUND

- A grower split their field between a GSP involving 600 lbs/acre 18-18-18 and a plant nutrition program that greatly reduced N, P, and K inputs

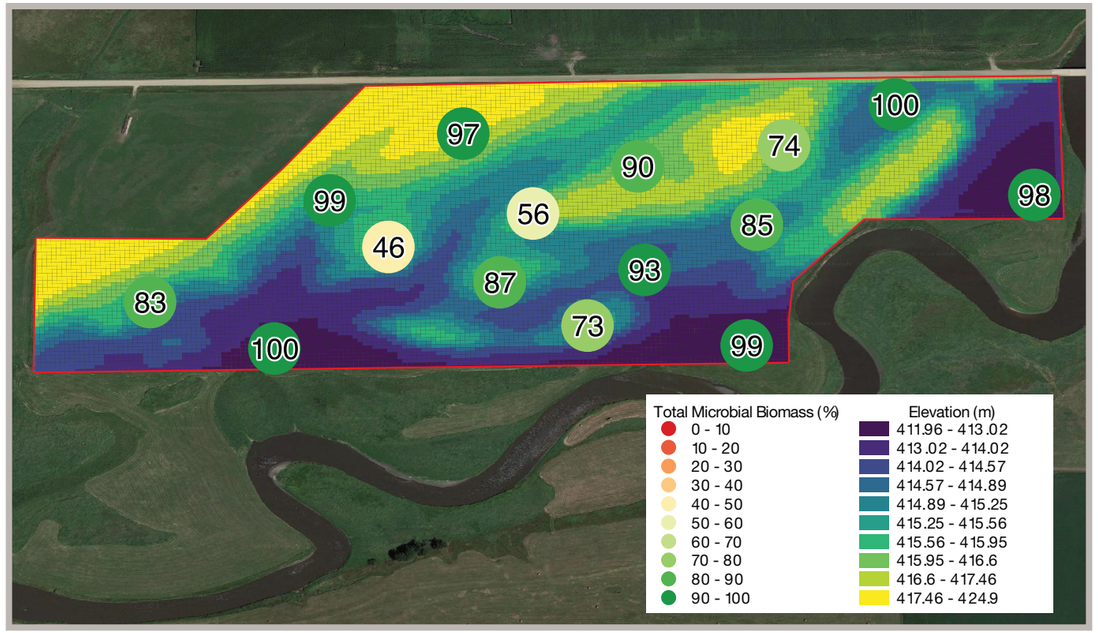
OM	pH	CEC
1.6%	7.3	24.0

TAKEAWAYS

- Despite lower applied N, P, and K, the plant nutrition program maintained yields at 1,500 cartons/acre
- The plant nutrition program increased most markers, but especially overall microbial biomass, P mineralizers, and P & K solubilizers
  - » Higher microbial biomass should improve nutrient mineralization and soil structure
  - » P mineralization and P and K solubilization make inaccessible P and K, like the P and K in residues, available to crops

IOWA

TOPOGRAPHY CAN DRIVE PATTERNS IN SOIL BIOLOGY



BACKGROUND

- A field in Iowa was grid sampled for soil biology testing

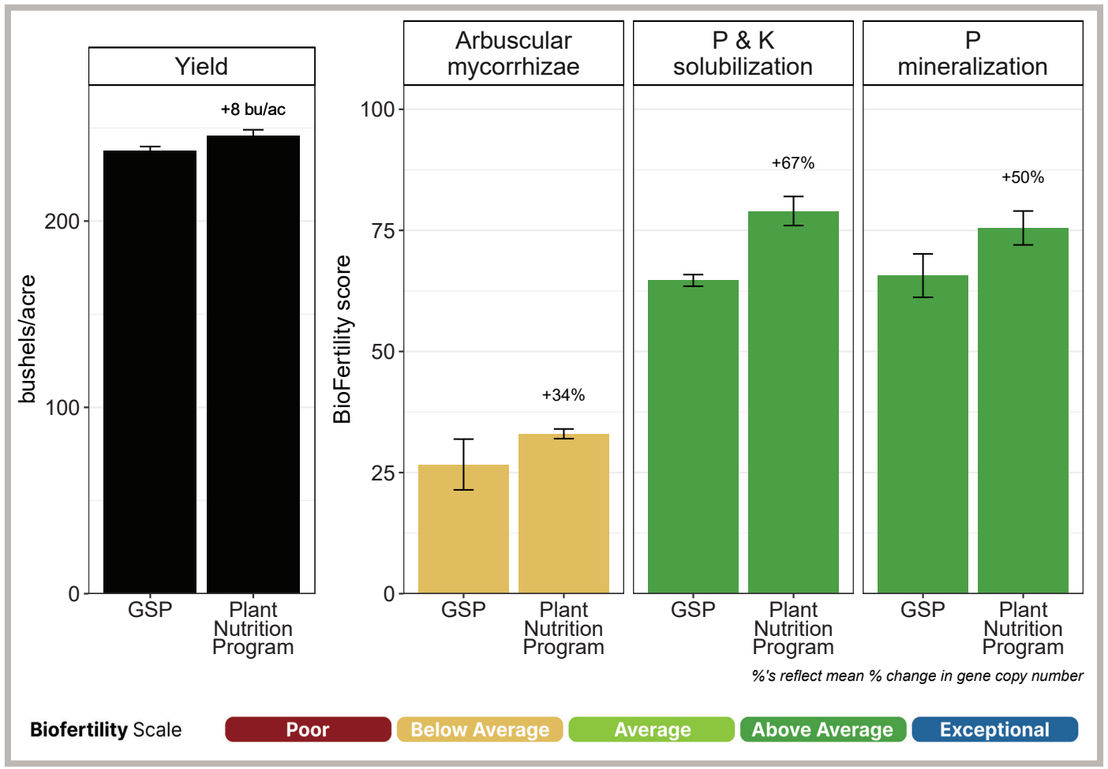
OM	pH	CEC	TEXTURE
3.7%	6.6	14.9	Loam; Sandy loam

TAKEAWAYS

- Microbial biomass metrics are all highest in low-lying portions of the field
  - » Rainfall and erosion can cause applied nutrients and topsoil to collect in low-lying areas
- Careful consideration of factors like topography is needed when deciding where to take soil biology samples, especially when those samples are being used to build field-level recommendations
  - » The usefulness of biological product recommendations, which are made under overall low levels of soil biology, may change if samples are pulled exclusively from especially low- or high-elevation areas

NUTRIEN AG SOLUTIONS INNOVATION FARM - KENTUCKY

PLANT NUTRITION PROGRAM IMPROVES THE ABUNDANCE OF P- AND K-CYCLING MICROBES FOR MONTHS AFTER TREATMENT



BACKGROUND

- Nutrien Ag Solutions Innovation Farm in Hopkinsville, KY has been applying 300 lbs/acre of 9-23-30 with or without an added plant nutrition product to corn pre-plant for 5 years

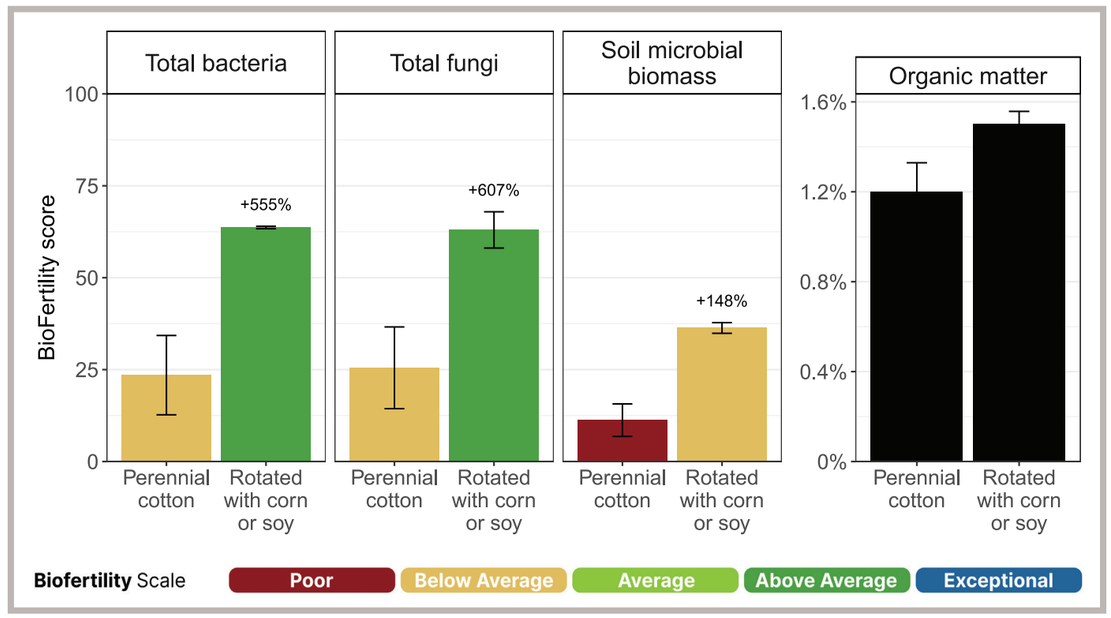
OM	pH	CEC	TEXTURE
2.8%	5.8	8.4	Silt loam

TAKEAWAYS

- This year, 1 month after application, a plant nutrition program increased available P by 36%, but had not yet changed soil biology markers
- At both 2 and 3 months after a plant nutrition application, even though available P levels became similar between a plant nutrition program and GSP fields, P-cycling markers were higher
  - » Both P mineralizers and P and K solubilizers create plant available P and K from organic and inorganic sources that crops cannot tap into themselves

NUTRIEN AG SOLUTIONS INNOVATION FARM - MISSISSIPPI

ROTATING COTTON WITH CORN OR SOY MORE THAN DOUBLES MICROBIAL POPULATIONS AND BUILDS UP SOIL ORGANIC MATTER



BACKGROUND

- At the Nutrien Ag Solutions Innovation Farm in Winterville, MS, three cotton fields have been rotated with corn or soy, while another four fields are continuous cotton
- All fields were in cotton in 2023
- Corn-cotton and corn-soy rotations can help introduce more nitrogen-rich corn and soy residue into the soil. These nitrogen-rich residues are more desirable food for microbes than the woody, nitrogen-poor cotton residues

OM	pH	CEC	TEXTURE
1.3%	6.3	10.9	Very fine sandy loam

TAKEAWAYS

- Compared to the continuous cotton fields, the three fields in cotton-corn or cotton-soy rotations had more than double the soil bacteria, fungi, and overall microbial biomass
  - » All that additional microbial biomass increases the soil's pool of mineralizable nutrients
- Fields in cotton-corn and cotton-soy rotations also had more organic matter
  - » Organic matter is strongly correlated with microbial biomass
- Management changes can have big consequences for soil biology

CONTACT

If you would like more information on soil biology testing, including how to submit samples, use soil biology testing in trialing, or interpret results, reach out to your Waypoint Sales Team Representative.

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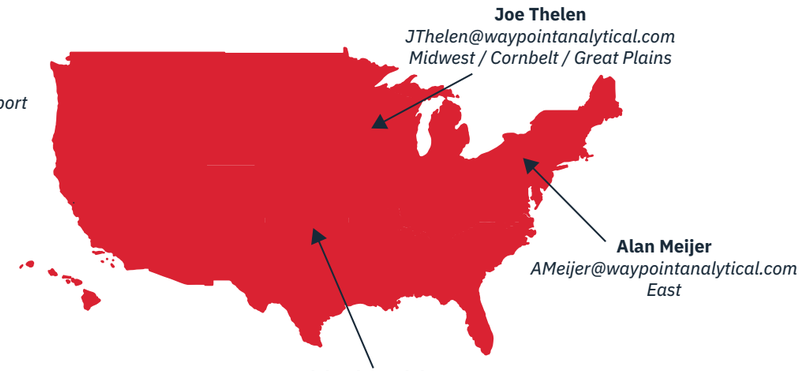

If you have questions about the report or your sample results, please contact:

Emily Tronson, ETronson@waypointanalytical.com or

Alicia Bryan ABryan@waypointanalytical.com