Improving On-Farm Return on Investment by Measuring Soil Biology

Featuring Meri Mullins

Technical Account Lead, Biome Makers

DJ May:

Welcome to the Decode 6 Podcast, where we take your questions about carbon and ecosystem services and match them to the experts with the answers. I'm your host, DJ May. Today we're asking one big question, what does soil biology have to do with your on-farm return on investment? Answering that question is our expert Mari Mullins, technical account lead at Biome Makers. Mari uses soil data insights to guide her clients through understanding how agricultural inputs influence soil functionality, giving growers and ag input manufacturers the tools they need to see the soil system through a biological lens. Mari holds a Bachelor of Science in Chemical Environmental Engineering from the University of Toledo.

She's worked in soil carbon markets, corporate sustainability, soil health education and policy, and ranch management. She spearheaded grassland regeneration projects at Lighthearted Ranch, and in 2018, founded Growing Resilience, a consulting group that deploys programs for carbon sequestration, ecosystem services and soil health. Finally, she's also worked with Antithesis, advising corporate clients on nature-based carbon removal strategy, specifically in climate smart agriculture. She's a great person to give us the details about what soil biology could mean for return on investments on the farm. So welcome, Mari. Glad to have you here.

Meri Mullins:

Great to be here.

DJ May:

Good. We will jump right in. So give us the background. What are we talking about when we're talking about soil biology?

Meri Mullins:

Yeah, so I get really excited talking about this topic, so you just slow me down if I start just talking so fast, you can't understand me. But when I think about soil biology, it's a core pillar when we're thinking about soil function and the importance of soil biology in agricultural production systems. So when you think about soil health, when you think about soil functionality, soil biology is one of those three key pillars. So we have soil biology, soil physics and soil chemistry. We've looked at soil chemistry and soil physics for a really long time. You think about water infiltration, you think about cation carrying capacity. You think about your chemical fertility analysis.

All of those things are connected by soil biology. So our chemistry in the soil, our NPK, our micronutrients, our pH, is all driven by biochemical processes or biochemistry. So the microbes in the soil are what move nutrients and make them available for the plant. They move nutrients to and from the plant, to and from the atmosphere when we think about our nitrogen cycle, it's all biologically driven, and now we have the tools to actually understand it better. So it's really exciting. So this whole new frontier of biological inputs and soil biology and soil health, it's all

driven by soil biology. Even aggregation and physics of the soil is influenced by soil biology and the different molecules that they produce.

DJ May:

Perfect. Yeah, I know. I've heard people talk before where the difference between just dirt and soil is soil biology. That's the whole thing bringing everything together. So that's a perfect summary.

Meri Mullins:

Yeah totally. You can think about this Venn diagram of three pieces where you have chemistry, physics and biology, and they're all interacting with each other and influencing each other. The soil does not exist without any one of those components.

DJ May:

Perfect. Yeah. So when we think about that in terms of plant health, what is soil biology doing to impact that?

Meri Mullins:

Yeah, great question. I love thinking about what the biology is actually doing. Why should we care? Why should we think about looking at the soil biology when we've just looked at the chemistry for so long? So the function in the soil, what the soil biology is doing is promoting plant health. Biology in the soil has created this very amazing interaction and evolution with plant exudates. So you have your plant photosynthesizing and producing sugars, and they use some of those sugars to build their own building blocks into lipids of the plant cell, but they're pumping a lot of those sugars, some plants like up to 50 or 60% of those sugars are going into the soil and feeding the soil biology. There's this beautiful relationship there, and they're doing that for a reason, because the soil biology is promoting plant health, promoting different functions in the plant soil ecosystem.

So some of those on an agricultural production system, we really want to be thinking about are things like nutrient mobilization. We talked about biochemistry a little bit. So our nitrogen, potassium and phosphorus are mobilized by biology. Our nutrient use efficiencies are driven by biology, so nitrogen or nutrient mobilization in general. So your micros and your macros are being mobilized and transported by soil biology, abiotic stress tolerance. So your plant is being supported by a soil ecosystem that provides it things like ACCD MNAs, silicic acid. It creates exopolysaccharides that help aggregate soil and increase water infiltration and drought tolerance. All of those are biological functionality. Abiotic, stress tolerance. Another function is hormone production, growth hormone production. So a lot of folks think of growth hormones, and they think the plant is producing all of them themselves. And we're talking about our gibberellin, cytokinin.

Those are also produced by soil biology. So that's another key function is growth hormone production. The plants don't do it all by themselves. They're feeding sugars to the soil and the biology that's eating those sugars for energy is feeding back hormones and minerals. And then the other function is pathogen resilience. And within that, we talk a lot about pathogens in terms

of whether or not they're there, but there's this whole other layer in the disease triangle that is plant health and what the soil biology is doing to help balance pathogens. Just because you have a pathogen present does not mean you're going to experience disease symptoms.

You have stress adaptive hormones, and you have beneficial microbes that are part and key components in plant health that are driven by soil biology. So what is soil biology doing to summarize? It's mobilizing nutrients. It's producing abiotic stress tolerance or hormones and metabolites to help plants cope with stress. And where it's producing growth hormones, obviously, to grow, to get out of the ground, to promote root growth, and it's part of the pathogen resilience pathways. So how can we be resilient to pathogen pressure? So those are the core functions of the soil biology as it relates to plant production and yields and agriculture production overall. I'm sure there's a lot of other stuff it's doing too, but those are the core functions that we're thinking about on a regular basis as it relates to ROI on the farm.

DJ May:

Okay. Well, I mean, hadn't quite made that connection with pathogens. It's so interesting to think about it because in bigger ecological systems where you can see it without a microscope, you can walk outside and look, whenever something's out of balance, that's when things go a little haywire. And that makes total sense. You might see that in the soil ecology too, with these.

Meri Mullins:

Totally. Totally. And I mean, you think of a couple real world examples that we can think of. So you have fungi in the soil that's naturally producing antibiotics. Penicillin is a great example. Soil microbes are balancing each other. We talk about soil health. People often talk about bacterial to fungal ratios. Why is that important? The bacteria and the fungi are communicating with each other, they're balancing each other. If you knock out your fungal communities, then you're going to have really bacterial heavy soils that may not be all the good ones that you want around, or vice versa. So yeah, thinking about disease and pathogen pressure more holistically, when we look at the soil biology, we get a bigger picture of the whole ecosystem. So we're not just identifying the pathogen because we're surrounded by pathogens all the time. We're not sick all the time. It's only when we're weak or we're stressed out that we actually have symptoms of the disease.

DJ May:

No, that's perfect. Well, I want to double back. You mentioned we've spent a lot of time thinking about soil chemistry and measuring it so that we can manage it. I've read way too many papers on soil physics at this point, but what about soil biology, what can we learn from those measurements?

Meri Mullins:

Yeah, so when I think about the new tools that we have in agriculture now to understand soil biology from the functional context, from the functions that we talked about, nutrient mobilization, stress adaptation, hormone production, pathogen resilience. So all those things, how do you understand them? We've been able to measure chemistry for a long time, and you can tell me what's potentially available in my soil. But here's the interesting thing about that, our

chemical fertility analysis, whether you have your mehlich-3, your haney, your base saturation, these different chemical extractions of the chemistry are meant to mimic soil biology. They're meant to show you what's potentially available to your plant that's ready to be digested and immediately fed to your plant. Now, I say potentially because it's only actually available if you have the proper mechanisms in the soil working and moving for you.

So a grower, we see this all the time, a grower may have a chemical fertility analysis that says they have so many units of zinc, calcium, manganese, whatever you name it, and then they do a tissue sample later in the year, and they're not having good nutrient use efficiencies or adequate uptake. Even though it's there, their plant tissue's still deficient. It happens all the time. Why is that happening? It's happening because there's a biological pathway that's blocked. So when we think about why is it important to look at biology and not just chemistry, your chemical fertility analysis only tells you what's potentially available. It's only actually available if you have the biology to move it and to make it available. So from a fertility standpoint, if we understand what biology is there to mobilize our nutrients and to support nutrient use efficiencies, then we can correct a issue and incorporate that insight into our fertility plan with a bio stimulant or an inoculate to address the problem before we have tissue deficiencies later.

The fertility's already in the soil. We don't need more of it if it's there, sometimes it's not, but most of the time it's there. But we need the biology to be working for us to unlock that. So they're a critical part of the supply train. They're the transport. So in terms of soil analysis and soil biology analysis, when you lay your chemical fertility analysis with a biological functionality assessment, now you have the full picture. Now you can answer the questions as to why isn't my chemistry moving? Or why are my plants really stressed? How can I promote the stress adaptive hormones, or how can I promote more nutrient mobilization? We run a BeCrop test but with a biological functionality assessment, you can really drill down into what is missing biologically, why isn't my chemistry moving optimally? Why do I have pathogen pressure? And answer those questions that we haven't really been able to answer before.

And we've been shooting in the dark to address some of these deficiencies. So some of the really common questions that come up, why do I have low tissue calcium when I have high soil calcium? Biological deficiency. Why do I have a really big yield drag in this side of the field even though the fertility's the same? We can explain that with biology. You overlay your biological analysis with a yield map. Wow. It's really cool. You are answering questions that we've had for years where it's like, why do I have yield differences in these fields even though I'm doing the same thing and the soil analysis is very similar? There's biological differences for whatever reason, and we can measure those, and then you can make more informed decisions with them.

DJ May:

Yeah, that's great. Well, talk me through some of those informed decisions. I know that nutrients are a huge cost when you think about what you have to put in as far as inputs. Yeah. Talk me through the return on investment when you start understanding where maybe these deficiencies are coming in.

Meri Mullins:

Totally. So when we think about like ROI on farm, where where's ROI driven? The two biggest factors are input costs and yield. So how do we maintain yield and reduce input costs? Or how do we maintain input costs but improve our yield? Or how are we balancing those things to maximize ROI on the farm? So when we're thinking about the importance of biology and answering that question, when you have biological insights, now you can answer the question of why do I have a 15% yield drag? And now you can address that. 15% difference in soybean yield is a big difference. You go from whatever, 30 to 45 bushels, that's a big difference. So if you can identify what the problem is, now you can quickly solve it instead of just guessing. And guys, when you're just guessing in agricultural problems and your first guess isn't right, you're going to have to wait a whole nother year to try something new again, not we have quick turnaround on solutions in solving problems.

So it's just this whole other layer of data to make more informed decisions on and understand some of our issues, and then also incorporate those solutions into our fertility plans or our management programs for the year, our input programs. So things like in year one, when I think about addressing some of these biological deficiencies that you might find, there are some great biologicals on the market. Which ones are good? That that's another thing that we work on, is getting through the snake oil and finding what biologicals are really doing something, and then being able to identify what your problem is and find the right solution to actually address the problem that you have. So now you can, whether you're maintaining inputs with the addition of a biological program and improving yields because you're increasing nutrient use efficiencies. If you have higher nutrient use efficiencies because you've improved biology, your ROI goes up.

If you're converting more nitrogen to higher protein in your grain, or you're converting more nitrogen that you're putting down into higher yields, that's a direct ROI. In the opposite, if you're cutting back nitrogen by 25% and maintaining yields still through improving nutrient use efficiencies biologically, that's direct ROI. Same with pathogen resilience. Man in potatoes, I mean, we're just working a lot in potatoes right now for example, potatoes are really susceptible to disease, but if you can understand it and improve their stress adaptation and improve and bring in beneficial bacteria or organisms that we know combat the pathogens that they're battling with, now you have more marketable potatoes.

It's a very direct ROI when you start to first understand what's going on in the biology, and second, understand what the issues are, being able to identify what the deficiencies are and then be able to make an informed decision from there what your solution's going to be. And then the last part of that is just tracking changes over time. Just like your fertility analysis, you're looking every year at your chemical fertility and you maybe just be doing the same thing, but if now you have this biological layer, we can now look at how we're changing, how our management practices are influencing nutrient use efficiencies, are influencing pathogen resilience, stress adaptive hormones in the soil biology. It becomes a really great indicator of how we're doing over time in tracking those changes.

DJ May:

Yeah, absolutely. Yeah. You can't manage what you don't measure, that old chestnut. Yep.

Meri Mullins:

Totally. And so it's exciting. We have the technology to do that now. We've looked at chemical fertility since the early nineties and just in the last decade really, we've been able to articulate biological functionality with high confidence. And yeah, it's supporting both agronomists, ag input manufacturers and the growers on the ground having more informed decisions and being able to validate what biologicals are actually working and what they're doing, if you're actually looking at how they're influencing soil biology.

DJ May:

Yeah. I just think it's a fascinating area to think about is we keep encountering all these challenges with abiotic stress and pathogens. I've heard so many times, even just in the last week about what we're facing in terms of pathogen stress and abiotic stress. And so whatever I think we can do to improve is great.

Meri Mullins:

Yeah, I mean, we didn't even dive into that too much, but in terms of ROI, what we have close to 50% wheat failures in 2022 in Kansas from high heat and drought. The farms that did really well were ones that had really high biological activity. They were more resilient to the stress that's just coming in the environment. Climate resilience is directly related to ROI as the conditions start to become more extreme. So I mean, that's a whole nother layer of like ROI. If everyone else in your county didn't harvest wheat, but you did, even if it was below average yields, you are doing pretty great this year by having the soil biology rocking for you and producing abiotic stress tolerance. Doing all right.

DJ May:

Perfect. Well, any final thoughts here before we wrap up?

Meri Mullins:

Yeah, I mean, I think we covered a lot of it, but just I would really encourage folks to think about biology. It can be this like, oh, I don't know, nerdy thing like, "Oh, the soil biology." We just haven't thought about it. They're not really talking about it, and it's like this woo woo thing or whatever, but it's a primary mechanism for moving your nutrients and producing nutrient use efficiencies, stress tolerance and pathogen resilience on your farm. So you're ahead of the curve if you start really thinking about biology and looking at the analysis and I mean, you don't need to run a fancy analysis. Start looking... Ray Archuleta always talks about using your shovel in your nose. Just start to tune in with the biological activity and what it's doing for you, and you can make really big waves.

DJ May:

Fantastic. Well, thank you so much, Meri.

Meri Mullins:

Yeah, happy to be here. Gosh, you could get me chatting about biology for a long time. You won't get me to shut up.

DJ May:

Well, there's always another episode, another day. Thank you.

Meri Mullins:

Yeah, it was fun. Thanks for the time.

DJ May:

Yeah. If this episode about soil biology piqued your interest, check out the show notes for more research. And if you have other questions about carbon and ecosystem services, don't be a stranger. Come visit us at decode6.org to learn more. We'll see you there.