Building organic matter without building phosphorus

Show Notes / Transcript
The Vegetable Beet
Episode title: Building organic matter without building phosphorus
Ben (00:14):
Welcome to The Vegetable Beet. My name is Ben Phillips and I work with Michigan State University Extension.
Natalie (00:20):
And my name is Natalie Hoidal. I work with The University of Minnesota Extension.
Ben (00:25):
How are we doing this, Natalie?
Natalie (00:26):
So this podcast is brought to you by the Great Lakes Vegetable Producers Network. It was kickstarted by the North Central Integrated Pest Management Center, and our license for Transistor is held by the University of Minnesota Extension.
Ben (00:39):
And you can listen to this episode and all the rest at glveg.net/listen. Enjoy the show.
Natalie (00:56):
Hi Ben.
Ben (00:57):
Hey Natalie.
Natalie (00:59):
How are you doing today?
Ben (01:00):
I'm doing real good. How about you?
Natalie (01:04):
Yeah, I'm doing well. I'm excited to share this next episode. So after last week's episode or the last installment of this mini series, we were talking at the end about how do we achieve these goals of building organic matter without way over fertilizing our soils? And so I reached out to my colleague, Nick, who studies soil formation, and just went into a really nerdy deep dive about how we build organic matter in our soils; the different ways to do that, the different time scales at which that happens. So I'm excited to share with you.
Nick (01:55):
So my name's Nic Jelinski. I'm an associate professor in the department of soil, water and climate at the University of Minnesota. And I am specifically within the discipline of soil science. My subdiscipline is pedology. And so pedology is basically the study of how soils form, understanding why they look the way they do and how their properties are distributed. So I love maps and I spend a lot of time looking at maps and thinking about maps. And the

interesting thing about soils too is that it's a three dimensional thing, right? So it's not as simple as making a map like we'd normally make maps that represent in two dimensions because there's also depth to think of in soil. So we do a lot, spend a lot of time understanding how those properties vary like in space, how they vary with depth.

Nick (02:50):

And then with soil formation, understanding how they vary with time. And by that, what I mean is not necessarily even human time scales, but time scales of soil formation, which can be anywhere from... There are processes that happen in soil on the order of days, weeks, months, years, but a lot of the soil forming processes are happening over centuries, millennia, 10,000 years, 100,000 years. So, think about a lot of different time scales and obviously linking that information to management. We're thinking about really short time scales and how those impact soil properties.

Natalie (03:29):

Awesome. That was a great introduction. Thank you. So the main thing that I wanted to talk to you about was this idea that we are often trying to change our soils very quickly by increasing our organic matter. And I think in part that's messaging from people like me in extension, celebrity farmers on Instagram. It's kind of coming from all over, that in order to be resilient, we have to increase the organic matter of our soil because organic matter holds onto water and nutrients. And so often that comes through practices like cover crops, but it also often, especially on smaller farms where this is more feasible, comes through like really heavy applications of compost and manure.

Natalie (04:14):

So I am hoping in this episode to really talk about that process of building up organic matter. So, just to start, a question that I often get an extension is, what is the ideal organic matter in my soil? What should I be shooting for? And the answer is always, it depends, which is never a very satisfying answer. So I'm hoping you can give a little bit more nuance to that answer. Like why does it depend, why do soils differ in the amount of organic matter they might be able to hold over time?

Nick (04:51):

You have probably picked the worst person to ask that question because this is what I love to talk about. So, I've got a lot of depth to my answer, so bear with me if I go down a few rabbit holes here. But what I would say is, to start with, in the research that I do, teaching that I do, we think about soil as... I think about soil as individuals. So, soil is a continuum across the landscape, right? It's a blanket of living sediment essentially across the Earth's surface. But at the same time, there are some discreet ways that we can... like when we make a soil map, we say, okay, this is this soil type, this is that soil type. We draw a line between them, but in reality, it's more of a gradient, right?

Nick (05:43):

But there are definitely differences between soils at multiple scales. So at a field scale, you've got individual bodies of soil that are going to behave differently based on the topography or the wetness, whatever it is. And then certainly as you get up to a county scale or a state scale or a continental scale, there's a lot of different factors that come into play that have influenced how that soil has formed. So I view every soil as like an individual and it's an individual and a gradient just like humans are individuals and gradients. We're more like our immediate family members and then we're a little bit less like our distant family members and then, right, and then the human family going all the way back, tracing our ancestors all the way back to some common ancestors. So soils are going to be more similar; the closer they are together and the more they share common factors.

Nick (06:37):

So when it comes to organic matter in soils, if we just think about natural processes that have contributed organic matter to soil, there is a huge variation, right? So, one thing maybe that's similar to the question that you said you get quite a bit, is that a lot of times people ask me like, how high should organic matter be in a soil? And I'm like, well, every soil is unique, so there's not a should there, right? Soils are what they are just as humans are what they are. Right. It's like asking like how tall should somebody be. Right. It depends on the person. They are what they are. So soils are the same way. So I think one of the things that we can do to escape this trap is to say, let's stop saying how much should a soil have, and let's think about instead, let's understand a soil as an individual and how it got to be the way that it was and its specific properties.

Nick (07:35):

So if you think about organic matter, there's basically a few main factors that have led to the amount of organic matter that was in that soil that formed naturally prior to human influence. So especially in the United States, we have a bit more of a benchmark on this than we do maybe in Europe or in Southeast Asia, or in Africa or in the middle east, where we've got agricultural soils that have been used for millennia, that you really can't separate out the human influence. It's harder to separate out the human influence from the natural influence. In the United States, because we do have such a recent land use, land cover change post European settlement, we can actually see the widespread impacts of agriculture on overprinted on the natural variability in soils.

Nick (08:27):

So if we think about just natural soil formation in the absence of humans, the main things that influence the amount of organic matter that goes into a soil are the climate. So how warm or cold the climate is, or wet or dry the climate is. That's a huge impact. The other impact is related to the particle size of the soil. So if it's a Sandy soil or a clay soil, that actually really matters. And the third, I would say more minor impact, is the type of organic matter that's going into the soil. Some organic matter is decomposed more quickly, others is decomposed more slowly, and so that matters a little bit. I would say if we're looking at our range of soils and understanding how certain soils became what they are, the main factors are going to be climate primarily and then texture, secondarily.

Nick (09:29):

And so climate is important because the way that I use soil carbon is it is a bank, right? It's not just what goes in, it's a two way street. So there's carbon that goes in and I should say also I'm using the terms organic matter in carbon interchangeably here. Organic matter is about half carbon. So that's why I use them interchangeably. So, if you have a soil that's about 6% organic matter, it's probably approximately 3% carbon. So there's approximately, right? So I may use them interchangeably. It's the same thing. Anyway, it's driven by organic materials being contributed to the soil. So, that's the flow in. Certainly anytime that plants die and their tissues are contributed to the soil, that's organic matter going in, but also plants contribute to organic matter going into the soil when they're living, because they are sloughing, like the root caps are sloughing.

Nick (10:26):

They're putting out dissolved organic compounds. There's a lot of things happening while they're living as well. So it's both plants living and dying that are contributing that organic matter to the soil. But those dead plant tissues are the really the big stock of organic matter in carbon that's going to end up building soil organic matter. So, depending on the climate that you have, that stock of essentially microbial food goes away quicker or slower. So in a cold environment and the other analogy is just to think about how we preserve food in our lives, right? So if I make dinner and I put it in the freezer, it's going to last for a long time. So if I'm in a cold climate and I'm thinking here, if we're talking about Midwest, we're certainly in a colder climate when it comes to agriculture, right?

Nick (11:20):

Like around the world, we have a colder climate here in Minnesota than a lot of other places in the world. So we tend to have higher levels of organic matter in general. There's a lot of other factors that play into it, but just in like a global basis, if we look at the amount of organic matter, amount of organic carbon in soils in Minnesota and the upper Midwest where we're colder, we tend to have more organic matter and it's simply because the microbes are working a bit slower because we're colder most of the time. So that's the two way street is how much goes in and then how much are the microbes burning off through respiration. And interestingly, it almost matters more that output is almost more important because, for example, some of the highest, some of the places where soil carbon is the highest in the world is in places that have low plant productivity.

Nick (12:14):

So the Arctic. For example, the Arctic Tundra, there's a lot of carbon locked up in the Arctic Tundra. So you're talking about short Tundra plants that grow for three months out of the year, but because the respiration, because the microbes are working so slowly, because the growing season's so short and so cold, a lot of that carbon gets stored in the bank. So, like Tundra soils, Arctic soils are almost, they're like [thrifty savers 00:12:41], right? They don't make a lot of money. There's not a lot of money coming in, but man, they are eating bread and peanut butter and jelly, rice and beans, right? And they don't go out much. They don't buy fancy cars and they're storing all that carbon. In warmer places, Southeastern United States, subtropics, tropics, and I'm speaking generally, of course, there's a lot of variability, but generally speaking in the world, the microbes can work all year round, right?

Nick (13:08):

So they can grow all year round. They can work all year round. They can decompose all year round. And so even though places like tropical rainforest, for example, there's a lot of plant biomass. There's a lot of organic matter going into those soils, but the microbes are working really hard all year round to decompose that organic matter. So in the end, there's not as much stored in the bank. So those warmer moisture soils are like, they're like big spenders, right? They make a million dollars, but they spend 999,000 of that million dollars, and so there's not a lot left in the bank. So climate on a global scale is super important. On a local scale, climate's also important in the micro climate sense. So if you're looking at a field, for example. The lower parts of the field where it's wetter are going to have more organic matter than the higher parts of the field, where it's drier. That's also a climate effect, but it's not usually related to temperature at the field scale.

Nick (14:10):

It's actually related to soil wetness. So it's the same principle there, but instead of microbes working faster or slower based on the temperature, that's an oxygen thing. So wherever the soil's wetter, you're going to have less oxygen available in the soil, and that means that microbes are going to work slower. They're still working, but they're working much slower because the soil's anaerobic. So climate is sort of this like broad, annual average temperature thing on a global scale. And then at local scales, it's really a wetness thing.

Nick (14:41):

And so all else being equal, colder wetter soils are going to have more organic matter than warmer drier soils. And a lot of that is due to the out path from the soil, which is the microbes and how hard they're working. So, in a natural sense, we have so much variability in carbon and organic matter in soil because we've got like... we can find soils where the natural soil organic matter content might be half a percent in the top, right?

Nick (15:11):

Or we have soils where the natural soil organic matter content might be 90% like in a peat bog in Northern Minnesota. Right. And so again, to the point, it's hard to ask that question, what is the ideal amount of organic matter? How much organic matter should my soil have? Because soils are individuals. And then we have this huge range and there's nothing wrong in a natural sense. There's nothing wrong with the soil that has half a percent organic matter that's developed naturally or not... or soil that has 90% of organic matter that's developed naturally. They're just different. They've just developed under different situations. So that's sort of like when I think about management impacts on soil, I think about first, like what are the bones? What is the natural state of that soil and how has management overlain on top of that? I think that helps us think about our expectations about how much organic matter should there be, or how fast can you push organic matter up, because there might be really different situations that people are working with. Sorry, I told you a lot of rabbit holes.

Natalie (16:17):

No, that was perfect. Thank you. Okay, I have three follow up questions based on your three factors. So the first factor is like just the climate and the place where you live. So I'm curious, some people talk about like, at least in the US; pre-colonization, soil organic matter levels as being kind of this benchmark. And of course those soils were managed before Europeans came here, but managed differently. And so does that feel like a valuable number to you or is that just like if they were managed differently, it's a different type of ecosystem. So maybe that's not a perfect goal. What are your thoughts on that?

Nick (17:07):
Yeah. So you made a lot of really good points there. I do think that it is useful in the sense that we don't really have any other benchmarks. And we know that certainly there were places where there was a lot of agricultural activity happening pre-colonization right. And so humans have been modifying soils in the United States, in North America for millennia. But the scale at which we modify soils now is very different, right? We have a lot of land in agricultural production with very intensive management and inputs. And although that has happened for a long time, the scale at which it is happening now is much different. So we don't really have any other benchmarks besides that pre-colonization, pre-settlement soil, organic, carbon, and that's why I'm trying to estimate that.
Nick (18:04):
And there's a lot of research that's gone into trying to look at, what would might that have been, how has it changed, and understanding that gives us one really valuable benchmark for understanding how soils may have changed since that time. Right. One way or another. And I would say that we don't really have any other benchmarks to lean on. So I would say that that's probably the most important one.
Natalie (18:29):
Okay. Is it a realistic goal though like say one landscape was like a prairie ecosystem and now it's a farm.
Nick (18:37):
No, I think that's interesting [crosstalk 00:18:38]. Well, I think that's a really interesting point. Is it realistic? Well, it's realistic in the sense that there were ecosystems, native plant communities that formed the soils that we now use and those plant communities fit into the climate and environmental factors in that area in that time. So if we think about like, what is something to aim for? Well, that's something that fit in very well with the environmental factors that were in place. And so, yeah, our environment's changing, but I think those benchmarks are still super important. And I think they remain realistic goals because that's what was basically there before really dramatically changing the land cover and land use and plant inputs and the types of plants that are grown, et cetera.
Nick (19:42):
So, yeah. Sorry to boil down my comments. I do think those pre-settlement, pre-colonization benchmarks are important. And like I said, part of it's just because they're what we have, but the other part is that I do think they're realistic for that place in time and they remain relevant, certainly.
Natalie (20:02):
Okay. Great. So one of the other factors, I think this was a third factor, was that different types of organic matter are more stable than others, maybe break down more quickly. Can you talk about that in a context of maybe things that we're doing to increase organic matter on farms? So cover crops versus compost versus composted manure, how might those things break down differently and have different stability for longer term organic matter inputs?
Nick (20:38):

Yeah. Yeah. Well, so from a natural sense, if I can think about things that have really different timeframes in terms of how long they're going to remain in the soil, just in terms of what they are, the identity of these organic molecules, on the one end of the spectrum you've got things like lignin and cellulose, which are these complex polymers. Lignin of course, being a major component of woody plant tissues. Right? And so that's really important because lignin has a complex structure and there's a lot of microorganisms that can't really break lignin down. And so there are some microorganisms that are really good at it. Like the white rot and brown rot fungi, there's other types of fungi that are really good at it, but then there's a lot of microorganisms that are not good at that at all.

Nick (21:24):

Right. And so for that reason, a complex molecule like that, it can be broken down. It can be decomposed, but it's going to take a bit longer just because you don't have maybe the same groups, abundance of microbes that are going to be able to start acting on it right away. If you contrast that with a simpler organic molecule that maybe has a lower carbon and nitrogen ratio, and by that, I mean has a relatively high amount of nitrogen. So organic matter always has a lot more carbon than it does nitrogen and microbes are always fighting for that nitrogen. So if there's not enough nitrogen in the organic matter that they're breaking down, they're going to pull nitrogen from the soil. They're actually going to take nitrogen from the plant available, pull in the soil and pull it into their biomass.

Nick (22:16):

If there's plenty of nitrogen in the organic matter they're breaking down, then they're actually going to release nitrogen in the soil because there's enough for them to pull in. And then as the organic molecule breaks down, that nitrogen gets released in the soil, the excess gets released in the soil. So if we think of something with a low carbon and nitrogen ratio, meaning it has a lot of nitrogen relatively speaking, and enough for microbes, those types of molecules are like ice cream to microbes, right? They'll eat them. And it doesn't matter if you're a bacteria or fungi or whatever, let's get to that. Right? It's like being at the old country buffet and the lignins like the dried, crusty lasagna at the end of the line that nobody's touched for 24 hours, you know what I mean?

Nick (23:03):

And the higher nitrogen stuff, the simpler molecules, that's the ice cream that everybody's going to have there. Right. And so we have this huge diversity of organic molecules, too many to count, right? The spectrum is huge. And it's those slight differences that can matter in terms of how long those molecules might stick around in soils. With our modern understanding, we used to think that there were some of those molecules that maybe they never really decompose. There's some concepts of really large, complex molecules that are in soils that are really, really difficult to decompose. I think most of the research now has shown that most of the organic molecules in soils are able to be decomposed, its just a question of how much time it's going to take.

Nick (23:57):

So now, if we think about those inputs that we might find under natural ecosystems, so, if you've got a forest and mostly woody inputs compared to a grassland where you might have fine root systems growing all throughout the year, a lot of those fine roots are turning over and dying and sloughing off and things like that. So you have this range of molecules that are being put in the soils. From a management sense, I think we can look at it in the same way, right? So things that have, relatively speaking, more nitrogen, meaning a lower carbon nitrogen ratio, that stuff's going to break down faster than stuff that has a higher carbon nitrogen ratio or less nitrogen relatively speaking. That's going to stick around longer.

Nick (24:50):

And one way to think about this would be, I'm sure folks have added wood chips to a garden or something like that. Right? And you can see those wood chips for years going on to the future. And if you add poultry manure, for example, or anything that's relatively fresh and has a lot of nitrogen and phosphorus, you're going to watch that disappear fairly quickly, right? It's going to get transformed into other organic molecules. And it will start not looking like the way that it was when you put it in there pretty fast. And so whether or not that is related to the actual amount of carbon in the soils, a separate thing, but in terms of the residents time of the molecules that you're putting in I would say that's the spectrum.

Natalie (25:47):

Okay. So I'm going to give you a scenario. So I was at the Moses conference a couple of weeks ago, and there was a really great speaker talking about soil fertility and soil health, who said that if you are using really good soil health practices, like cover crops and reducing tillage, you can realistically expect that your soil organic matter might increase by about 0.1% every year. A lot of vegetable farmers have increased their soil organic matter by like two, 3% over just a couple of years by using heavy compost inputs. And so I'm curious to hear from you, what would be the functional difference in soil or in the longevity of the organic matter, in a situation where someone has primarily used cover crops over time to increase their organic matter slowly versus someone who has increased their organic matter in their soil relatively quickly using heavy compost editions.

Nick (26:53):

So I think that's a great contrast because, so what we're doing, so when you're bringing in compost, for example, you're actively adding large amounts of material to the surface of that soil, and then mixing it in with tillage obviously. The material that you're adding is like 95% organic matter, right? So compost is organic matter. And that's been cured in various ways, right? So basically, you're adding a layer of organic matter. So in soils, in pathology parlance, that type of compost, something we would call a compost is what we would call an organic soil material. And I want to make a definition here. So we make a divide approximately in understanding natural soils, between things that we call organic soil materials and things that we call mineral soil materials. All natural soil materials have mineral stuff in it, sand, silt and clay, and they have organic matter, but the percentage of those things varies widely, right?

Nick (28:00):

So like I said before, you could have a soil that has half a percent organic matter or less. You could have some soils where most of it is organic matter, and there's almost no sand, silt and clay in there, right? So we use this cutoff at approximately 30% organic matter. Anything that is 30% organic matter or more, we call an organic soil material, and anything that's less than

30% organic matter, we call a mineral soil material, recognizing that all soil materials have some organic matter in some minerals, but it's just a quick way to reference those things. So compost, in that sense, we would certainly call an organic soil material. So the way that—so what compost essentially mimics in the natural world, the places where we naturally get soil materials that have organic matter that high are peat bogs and wetlands. Okay?

Nick (28:52):

So that's the only place where the climate, the environment is cold enough or wet enough that microbes work slowly in the natural soil to allow organic matter to build up to that extent without decomposing. So when I think about composts from just the perspective of natural soil development and non-human influenced soil development, what is really happening is compost is an organic material. It's a very organic matter rich material. And so when we're doing heavy applications of compost, we're essentially just adding a layer of organic material to that soil. So it's not surprising that the organic matter would shoot up, because in the natural world, if we've got a soil that has, let's say 20 centimeters or a foot of peat over maybe a glacial sediments, and we measured the organic matter going down with depth, we might have 90% organic matter, 90% organic matter, 90% organic matter, going down to a foot.

Nick (29:59):

And then when we hit those glacial sediments, we might have half a percent, right? It's all just the way that the soil is stratified and layered. So what we're essentially doing when we're doing heavy applications of compost, we're just adding a layer of organic materials to the surface. And so it's not surprising that you would see a really rapid jump in the organic matter levels that you're measuring because you're adding this really organic, rich material to the surface. And yes, you're mixing it, but most tillage implements, you're not actually mixing it that deep in the sense of the full depth of the soil. So a lot of that organic material is staying fairly shallow. So I think that's an example-

Natalie (30:37):

[crosstalk 00:30:37] you have to continue that practice in order to maintain that level of organic matter?

Nick (30:43):

In theory, yes. So, in theory, to maintain it indefinitely, yes. But I think some of that organic matter, it's not like all—so let's say you added that organic matter one time. Right? And then you just let it be, and you did your thing and you measured organic matter going through time and watched what happened. Right? So it's like an exponential decline. So you might see more rapid declines in the first five years or so. And then as you got out to 10 years, 20 years, 50 years, you would still have more organic matter in that soil than you started with, but you're going to get less and less and less and less over time. So in theory, yes, if you want to maintain the same amount, you're going to have to keep adding, and that's the other thing I think with these expectations for how much should I keep building?

Nick (31:34):

Well, there's a point where you're going to hit the limitations of the natural environment or the amendment that you're adding and it's not going to go up anymore. Right? You could keep adding all you want. And it's not going to ever be more than the material that you're using as the input to begin with. Right? That's your absolute cap, but then overlaying on that is the environment. So again, how fast, if you had a field that was a hill slope, right, and added the same amount of the same input from the summit to the foot slope, to the bottom, you would over time, build up a lot more organic matter in that bottom than you would at the top of that hill slope. And again, it's all due to the direction, there's microbes that are working longer and harder because the soil's going to be warmer and dryer at the top of the hill slope.

Nick (32:25):

So yeah, sorry. So in theory, yes. Understanding that the environment matters too if you want to maintain that level in a well drained soil where the microbes are working hard, you're going to have to keep adding that organic matter over time. If we go to the other management practice that you mentioned, which is just, okay, let's say now we're just going to cover crap as our way to increase soil organic matter. So there, I think the speaker that you mentioned that Moses, I think that to me sounds just from the world of soil sense, setting a goal of 0.1% per year. That seems pretty realistic I think to set expectations higher than that for not bringing in massive inputs of organic matter, because you got to think, cover crops is not the same as compost, in that cover crops, you've got a living plant that is adding organic matter to the soil but has a wide range of molecules in it that those plant materials are going to start being decomposed.

Nick (33:30):

Compost is also cured. And so it's already been through this process of microbial decomposition from the raw material. And so that's going to decompose slower than your cover crops, which are going to have this lower carbon nitrogen ratio, higher relative amount of nitrogen, they're going to be yummier, right? So those cover crop residues are going to be a bit yummier than maybe the cured compost. And so I wouldn't be surprised if the amount of time it took for those things to break down would be different. And also you're not adding in the example of the cover crop. You're not adding a layer of organic materials, right.

Nick (34:14):

You've just got growing things that are eventually going to be incorporated into the soil. So your time to increase the organic matter is going to be much higher for that reason. And going to your question of, is it more sustainable in the long term? Boy, that's beyond, I don't want to speculate on that. I would ask somebody that does that kind of research, but I do think just in terms of thinking about the rates of increase. Yeah. That makes a lot of sense to me. Sometimes I think maybe we expect too much out of a soil because remember it's not just the management, if there's one thing that I always try to get through to folks, because I look at soils from the other way, right? I look at the natural soil and then try to understand how the management is overlaying on that.

Nick (35:00):

But I think we have a tendency, especially in agriculture to think our management is the thing, right? What we do in management is what makes the soil and yes, management has a huge impact on the soil, but you also have a soil that's an individual or a set of soils in your field that are individuals that are their own entities that are what they are, and you're

interacting with them. But what you are doing just in terms of management is not what makes that soil. There's a lot of other things that are happening there. And again, at a field scale, you could have widely different soils that are going to react in different ways to the same management. And that's where I think the expectations can get off track because people are maybe expecting that just because it's the same field, all the parts of it should behave in the same way. And that may not necessarily be true.
Natalie (35:55):
Yeah. Yeah. That's a great point. So I think that's a good segue into this last question. So I think often we are using organic matter as the measure of whether our soil is healthy or not. And I know we've had these conversations, I'm always thinking more about the chemical properties of soil and organic matter, and you've framed soil health as broader than that, looking at things like bulk density and other physical soil characteristics. So I was curious just to see if you had any other metrics that people could be thinking about as they're looking at the health of their soil over time beyond just using organic matter as the primary proxy for soil health.
Nick (36:41):
Yeah. Oh for sure. I think that's a really good question, and I agree. I think our focus has been and for good reason, right? There's a good reason that we're focusing on organic matter. I think, sorry, I might go down another rabbit hole here.
Natalie (36:54):
Okay.
Nick (36:56):
You can edit me out if you want to. I think that the reason that carbon organic matter is so central is because carbon into soil is energy into soil. So, organic carbon is a store of energy, just the same way that we go to the grocery store and buy food and eat that, right? Organic matter in soil is food for microbes. And so organic matter in soil is what drives the terrestrial food web. And the crazy thing about organic matter in soil is where the energy comes from that organic matter, the carbon actually originally was carbon dioxide in the atmosphere, right?
Nick (37:33):
So plants took that carbon dioxide in the atmosphere and with their photoreceptors and their amazing photosynthetic systems, they used high energy particles that are flying from the sun, 93 million miles to the earth. And that energy from those particles from the sun is what ends up embodied in the soil organic matter. It's just crazy, right? So organic matter going into soil is solar energy stored going into soil. And so the reason the focus is so heavy on organic matter and carbon as the main thing we think about in soil health, is because it is true that organic matter organic carbon is the central store of energy in a soil. And it's going to be what drives the soil food web. So generally speaking, if you've got more organic matter, more carbon, you've got higher microbial biomass, you've got a faster functioning of some things, you have, maybe more nutrients and things like that.
Nick (38:33):
So we focus on that and there's a reason we do. But I think also to your point, sometimes it

can be to a detriment because we don't think about the whole soil system. Soil is more than just the amount of organic carbon in it. We've got inorganic materials in soil. We've got sand, silt and clay, we've got a lot of nutrients that are inorganic. We've got a structure to soil. We've got an architecture, we have pore space and aggregates, right? And all those things together influence the function of a soil. So there's a really great analogy and, I don't want to misattribute the quote, so I'm going to forget who said this, but this is not my quote. But it's that essentially the way that we measure carbon, a lot of times other nutrients in soil, the way that we measure those is we take a soil sample.

Nick (39:28):

We dry it, we grind it and we put it in a furnace and burn off the amount of carbon in matter, right? So we get an amount of something that was in there. That's like trying to understand how a house functioned. If you didn't know how a house functioned and you were trying to figure it out, that's like saying, okay, let's wreck the house, grind it all up and measure how much, I don't know, of something was in there, right? We missed the whole function of it. So carbon and organic matter isn't certainly the most important indicator of soil function. I don't want to say that it's not, it is certainly, and there's a reason that it's central and more carbon, more organic matter, generally speaking is going to be associated with higher capacity for functioning in that soil.

Nick (40:20):

But it's not the only thing because soils are a whole system that has a physical, chemical, biological components to it. And so if we think about the other things that might be really important besides just understanding carbon, I think a lot about soil architecture. So soil structure aggregation, super important because that's related to how susceptible soil is to erosion, is related to iteration, how well oxygen can get down to the roots, how quickly is water going to drain? It's related in a lot of ways to wear microbes, so soil structure and how microbes are distributed in the soil is also associated with each other. So that architecture is really important. And so, as an example, you could have two soils that have the same amount of carbon or organic matter that they might function really differently if their architecture is very different.

Nick (41:16):

And you might not be able to know that from the carbon or organic matter alone. Now from a global perspective, again, like I said, soils that have more carbon or organic matter are more likely to be better aggregated to have more pore space, et cetera. But it doesn't mean that every individual that has a higher amount of carbon or organic matter is going to be like that, right? We can still find wide differences in architecture. So I think that architectural piece is really important thinking about the soil as a physical piece of architecture and how the management that we do influences that architecture for better or worse from an agricultural perspective. That's super important. Nutrients, similar thing although a lot of times, especially in organic production systems and other systems, nutrients are closely tied to the amount of organic matter you have in the soil.

Nick (42:09):

So a lot of times there's a correlation there, not necessarily though, especially there's micronutrients and other things you can get into where the disconnect between the amount of carbon and organic matter in a soil and the amount of that nutrient can start to be pretty disjointed. Nitrogen is usually pretty tied to the amount of carbon in a soil. So you can guess that nitrogen fertility based on the amount of organic matter in the soil. But anyway, so there's certainly some disconnects there. We're only just beginning to understand the full range of the biological community in soils. Literally just with genomics, now we can break open what has been a really opaque box of who are the microbes that live in soils and what are they doing, and when are they doing it?

Nick (43:01):

And it's such a dynamic and diverse system that it's very difficult to understand without the tools that we have. So we're just on the verge of really understanding that aspect of it. And so I think a lot of times we're biased to the things that we can measure easily. And there's a reason that they're important, but we're missing sometimes this architecture and understanding the biological community and we have a lot of knowledge to gain in those areas, too.

Natalie (43:27):

Would you say for measuring, trying to understand that architecture in your soil? I know NRCS has tests that I think most farmers are pretty familiar with, like this lake test and infiltration test. Are those the main things you would recommend people do?

Nick (43:46):

Yeah, I think yeah, the NRCS toolbox is really good for that. So definitely understanding soil aggregate stability with slaking is one really easy way to look at that. And then infiltration is obviously super important, right? It's an indicator of the architecture and the structure. In theory, if you've got a really compacted soil, you're just not going to have the same infiltration. And, again, that gets to multiple functions, right? So even infiltration, a lot of times we focus on just infiltration, but if we step back and say, okay, infiltration is really an indicator of the soil architecture and all the other things that happen with that, right. So it's not just how fast water goes into soil. It's how fast oxygen can diffuse down to plant roots. Right?

Nick (44:29):

And so there's a lot of aspects where when we're making these measurements, we're looking at indicators of a whole system. And I think the architecture's a great example of that. And yeah, I would agree that probably infiltration and slate tests are the easiest to understand there and actually do in the field. There's other things like visually evaluating soil structure and putting that in different classes and looking at, for example the size distribution of different soil aggregates, those are more complex and we usually need some laboratory methods to do that. But there's other ways that we can look at that too.

Natalie (45:08):

Okay, great. Well, that was all my questions. Thank you so much. Is there anything you wanted to say, but didn't get a chance to say?

Nick (45:19):

No, not at all. I feel like I said too much. I apologize.

Natalie (45:23):

No, that was great.
Nick (45:26):
Sorry, you get sucked down rabbit holes sometimes, but really, I appreciate the opportunity to talk soils and specifically to think about how, like I said, management is overlaying on these natural factors that have formed the soils that people interact with. And I think shifting our perspective in that way, from this really human centered, like what we do is what it is, to what we do has an impact, but it's overlaying also on all these environmental factors. I think that gets us to the next level of talking about soil health, thinking about soils as individuals, managing for soil health on a field scale in diverse ways. That's the thing that I think is hopefully the future. And I hope that our basic understanding of pathology and just the beauty of soils and how widely diverse they are around the world is going to be a piece of contributing to that conversation. So anyway, I appreciate the opportunity to talk about it.
Ben (46:40):
All right, Natalie, that was a great interview and I took two pages of notes on it. We don't have to go through it all, but man. So Nick's got a way with words, doesn't he?
Natalie (46:53):
He does. Yes. Nick has got like TED Talks about soil. He's a well practiced soil enthusiast.
Ben (47:03):
One thing I was thinking about was he had talked about how basically the two things that make organic matter is lignin, which is a woody material and cellulose, which is another carbon rich molecule coming from more of the herbaceous plants. And also I was thinking like, well, what about manure? But what is manure other than just masticated-
Natalie (47:28):
It's broken down.
Ben (47:29):
Yeah. It's just pre-chewed. It's still cellulose and lignin. But it got me thinking, I remember out on the muck in Imlay city here in Michigan, I was talking to some growers out there and they said, every couple years they'll be doing some tillage and they'll basically uncover a piece of a large tree that's just been there since this was a floodplain for centuries. And how the lignin is still there. And until it was drained, it was a highly anaerobic, saturated environment, which as Nick pointed out, slows down the microbial activity that creates organic matter, but preserves it in a way. And so that lignin was basically preserved like a bog person in Scotland or something.
Natalie (48:23):
Yep, yeah. That is it. We don't really have muck soils in Minnesota, at least that are used for agriculture. So that's not something that most of us are familiar with, but in Michigan, parts of Ontario, you are probably all very, very familiar with, yeah-
Ben (48:40):
It's a really bizarre place.
Natalie (48:42):
Some of those concepts of how organic matter is stored. Because you see it so clearly in the fields that you're working in.

Ben (48:47):
Yeah. When you go through a wetland that's still a functioning wetland, you don't even think about what the soil is really like if it didn't have all the plants that it has and it wasn't drained or if it was drained. And then when it's drained, it's just pitch black soil that is super light and fluffy and blows away. It feels like you're walking on the moon, almost. Like a black moon. It's really weird stuff. And it's always going away, which is the unfortunate part. So it's just always blowing away. It's getting burned up by my microbial activity. It's just always going lower, lower, lower, lower.
Ben (49:24):
So as you and Nick talked about organic matter, re-contribution is on the minds of these muck growers all the time and cover crops are being employed to try to get some of their organic matter back. So, another takeaway I had from Nick that I thought was interesting, and I'd like to hear if you got this too, was he really impressed upon me, how different soils will take to management practices differently. And so to use just the very basic metric of organic matter as some kind of badge of honor across different soil types, isn't probably as useful as we all think it is.
Natalie (50:15):
Yeah. There was one thing. It was a really brief thing that he said about how we maybe expect too much of our soils. And that really stuck with me because I think often, I'm in a lot of conversations about climate resilience and working with farmers for developing plans for their farms to be more resilient to climate change. And building soil organic matter is almost always in the top three priorities. And so there's this idea that we have to build organic matter because it's going to store nutrients, it's going to store water. It's going to allow us to better withstand bigger storms.
Natalie (50:51):
And I think that idea that that's a lot of pressure to put on your soil is interesting to me that there are so many other things we can be doing on our farms to do those things like planting rows of perennials to absorb some of that water and other big picture strategies like that. But we put so much pressure on our soil to do all of that work for us sometimes without maybe thinking of broader, like taking an ecology perspective and thinking of like landscape level ways to be resilient. So I know that's not exactly what we talked about, but that's something I've been thinking about following this interview.
Ben (51:32):
Yeah. Yeah. Nick mentioned how architecture of the soil and soil particle size has an incredible impact on what you can do in a soil. And not just what you can do, but how you can grow in different ways. And if you're essentially trying to take a soil that's super sandy and make it a loam or if you're taking a heavy clay soil and make it a loam, you're never going to get there. And I see a lot of growers who are new or they've just gotten some land and a lot of Facebook groups that I'm a part of, there's always some kind of preamble before asking for advice where it's like, got this property, the soil's terrible and we're improving it. Sure. I'm sure you can improve it. Right? But if you think that you have to wait until it's improved to start.

Natalie (52:27):
Yeah.
Ben (52:28):
I don't think you're going to see the benefits that you're hoping. Because the soil is so, oh my gosh. It's like trying to turn the Titanic or something versus a speed boat. You're just not going to get it to move into the direction you want so quickly.
Natalie (52:43):
Right. In the last episode we talked about the Instagram farmers, these beautiful farms where they have really fluffy, perfect beds and yeah, rather than feeling like everyone should be getting to that point and setting that as the standard, just better understanding the soil where you're at and how you can work with that soil seems like a maybe more balanced approach.
Ben (53:10):
Yeah. And theres a quote that I've always resonated with. I don't know who said it, but its style is defined by limitations. You're just going to have to develop a style that's going to work with the limits that you have. You can only go so far to copy some other system and paste it right onto the land that you have.
Natalie (53:30):
Right.
Ben (53:30):
It's just so... the earth is, it takes forever to get to the things that you have that you can observe in your lifetime. And to change them in your lifetime, it could be an exercise in futility to think too grandly about what you can change, but yeah.
Natalie (53:49):
And it's still worth it. I don't mean to hate on those farms too much.
Ben (53:55):
No, I'm not hating on-
Natalie (53:55):
It's still a really worthy goal to be using cover crops as much as you can, be working towards that organic matter. But yeah, have more realistic expectations and think a little more broadly than just set a number.
Ben (54:10):
Yeah. Yeah. I don't want to discourage someI don't want to make people think, oh, it's hopeless. So I'll just till all the time. I don't think that's the answer either.
Natalie (54:18):
Yep.
Ben (54:18):
I don't think that's the answer either.
Natalie (54:21):
Right.
Ben (54:21):
Well, this was a great set of talks you had here. I really enjoyed watching you go from the

first episode, just thinking about what's up these hoop houses, and then following those leads and those questions with more people who knew different things and hitting it from all these different angles.
Natalie (54:41):
Yeah. It was fun to have the platform and the excuse to really explore and take a deep dive, so.
Ben (54:49):
Yeah, it's an interesting format that allows us this leeway and creative time to get into things.
Natalie (55:00):
Definitely.
Ben (55:00):
All right. Well, thanks, Natalie. That concludes this episode of The Vegetable Beat. If you'd like to check out all of our past episodes, head on over to glveg.net/listen. Bye.

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vegbeet s03e04 (Completed 05/12/22)
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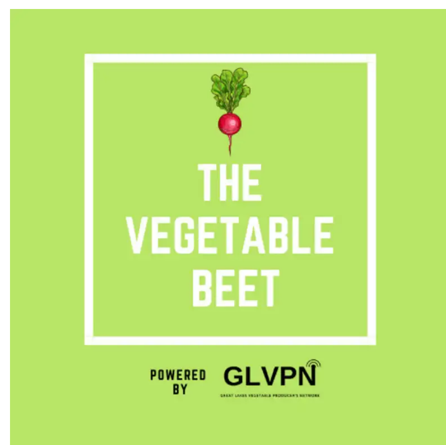

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