Episode 1: What does organic matter do for soil?
Full transcript

Hi everybody, and welcome to the Priming for Production podcast. I'm Natalie Lounsbury and this episode is the first of not one, not two, but four episodes devoted to soil organic matter.

> ***Johannes- Soil organic matter is one of the, if not the, foundation of soil functioning, soil fertility, soil everything. It's the foundation of soil health and how carbon and nutrients cycle in soil. So understanding soil organic matter is really fundamental to understanding soils.***

That's

> ***Johannes Lehmann I'm a professor of soil science at Cornell University.***

Johannes studies soil organic matter, so he's certainly biased, but it's not an overstatement to say that understanding soil organic matter is really fundamental to understanding soils, which is exactly why I'm starting here. You'll hear more from Johannes in the future. He'd probably be a bit embarrassed to hear me say it, but the guy is kind of a soil organic matter rock star, so I can't wait to get back to him.

The subject for today, the starting point, it what does organic matter do for your soil? There are physical, biological, and chemical components to what organic matter does, and that's what we'll explore during this episode.

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Throughout the podcast, you'll hear a lot from my former advisor Ray Weil.

> ***Ray-I'm Ray Weil. I'm a soil scientist at the University of Maryland where I've been for almost 35 years now, and I work with a lot of farmers in the mid-Atlantic region and around the world actually, and I'm probably best known for being co-author of the Nature and Property of Soils, which is kind of the classic soil science text book.***

I know it would be an easy sell if I just made a blanket statement that organic matter will increase yields or save you a certain amount of money, but it's complicated. Ray is quick to point out that even soils without much organic matter, what we might call degraded soils, are capable of producing high yields.

> ***Ray-It's not to say you can't get high yields from a degraded soil. There are high yields being produced all over this country from soils that are quite degraded, but they're produced at a cost.***
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> ***The soils are less resilient so they're going to be more susceptible to stresses, especially drought stress. What organic matter can do for you is allow you to increase your yields of crops at a lower cost, both a lower financial cost, you have to buy fewer inputs whether those are organic fertilizers or inorganic fertilizers, and you'll be less susceptible to vagaries of weather because you'll have more water holding capacity, you'll have deeper root systems. For most kinds of agriculture, the number one limitation for plant production is water.***
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> ***There's not much a farmer can do about the texture of the soil. If you've got sandy soil you've got sandy soil and it's not gonna hold much water, but if you build organic matter, that will greatly increase the water, 2 or 3 or 4 times as much water in a sandy soil that's high in organic matter compared to a sandy soil that's had the organic matter depleted.***

Let me just say that again. Sometimes we get hung up talking about nitrogen, phosphorus, and potassium but for most kinds of agriculture, the number one limitation for plant production is water. And water dynamics and organic matter go hand in hand. Organic matter can help buffer differences in yield between wet and dry years and can help sustain crops during periods of weather extremes for a number of reasons. This is more important than ever. In Maine, my home state, the weather data are showing some trends that are hard to ignore if you're trying to run a farm.

> ***Ivan- We've seen about a 13% increase in precipitation in the last 100 years and we expect to see pretty much that continue. What's noteworthy is a lot of the increase comes in intense precipitation events and the last decade has been remarkable relative to the amount of intense precipitation events which makes it really erratic. So the weather is really erratic, the amount of water we have to manage is really erratic.***
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> ***I'm Ivan Fernandez, soil scientist faculty at the University of Maine. And I've been here for a long time. 32 years.***

Alright, so if you didn't get the idea, the word of the day when it comes to weather is erratic. The erratic nature of precipitation means that there may also be longer period of dry weather between rain events. With these kinds of intense rainfall events and dry periods, we need our soils to do two things with the water.

> ***Charlie- It has to be able to infiltrate and get into the soil and then once it's in the soil you want to hold it there. You never know when the next rain storm will come so you really don't want that water to run off the field. You want the soil to absorb it and hold it.***

Charlie White is a research associate at Penn State who has worked with a lot of farmers. When I spoke with him, he was working on his PhD.

Both of these functions, allowing the water into the soil, and holding it for later, are enhanced by having more organic matter because the amount of organic matter

is closely related to an important physical aspect of the soil: aggregation. Instead of individual particles of soil, which are really, really tiny, aggregates are those nice crumbs of many soil particles stuck together that you can actually see. Organic matter helps hold these particles together, maintaining the aggregates and a healthy amount of pore space within and between aggregates. You may have heard that a healthy soil is about 50% pore space, so half the volume at any time is filled with either air or water! Good aggregation is key to maintaining pore space.

> ***Charlie—Those water cycling processes are all about having good aggregation of the soil and good aggregate stability so that your macropores don't dissolve away and also so that when you get these heavy rainstorms you don't get a lot of erosion and soil loss which you know causes water quality issues but also on the farm that's your topsoil and you may have worked hard over many many years to build up that topsoil, build up the fertility of it, build up the organic matter content, and if that erodes away from you that's something you can never really recapture.***
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> ***You also want the soil to be able to drain because of course roots need air to live and so you don't want the soil to be saturated, so you need to have those macropores in the soil that will drain quickly and allow the soil to be well aerated, but you want the aggregates that are filled with micropores that are gonna hold the water as well and be a storage reservoir.***

In other words, a well-aggregated soil relies on the small pores within aggregates, the micropores, to hold onto water like a sponge, while also relying on the large pores between aggregates, the macropores, to allow excess water to drain.

I want to keep coming back to the question of what does organic matter do for your soil? What is its value, or, perhaps, why should we invest in building organic matter in our soils?

> ***Ivan-The biggest payback comes in the extremes. If you get big thunderheads at your place and you get a lot of rain in a 3 or 4" event when the soils are sort of wet early in the growing season then you're***

> ***going to get a big payback for everything you've done to improve your soil health and aggregation such that it is more resilient to erosion because you can be sure you're getting accelerated erosion during that event. And the folks that have poor soil structure are going to lose a lot more soil in that event. Point being, it's the extremes. It's the really hot August that gets really hot, you know high heat index days for three of them in one month, a remarkable event, the soils that had the best soil organic matter are going to hold moisture the longest and those plants are going to be better off.***

In addition to helping with water dynamics, good aggregation also make soil less susceptible to compaction, which can happen from large equipment or even just the many feet of people harvesting in the field. When a soil gets compacted, the pore space is reduced, and water can't infiltrate as well, and the soil can't maintain enough air for plant roots and soil organisms to thrive. So, this brings me to yet another function of organic matter in soil: its role in supporting soil organisms.

> ***Ray- Probably the most important thing organic matter does is serve as food for all the organisms in the soil that provide this community support for the plants and for the crops that farmers are trying to grow. You can grow pretty good plants hydroponically in clear water and nothing but dissolved chemicals with no organic matter at all, if you control everything else. If you want nature to do some of that for you, then you need to be able to feed the natural system.***

Nowadays it seems like everybody is talking about soil biology, but that hasn't been the case for very long.

> ***Ray- In the 1970s, any time I gave a talk to a commercial farming, they definitely didn't come and ask me to come and talk about soil biology. They wanted me to talk about fertilizers, soil testing, or something like that.***

Not anymore! People are excited about soil biology, but it's a hard ecosystem to visualize because there are organisms you can see, like earthworms and mites, but the majority of the organisms in soil are the ones you can't see, like fungi and bacteria. The important piece to remember, like any ecosystem, is that they all have to eat. A few of them are pests and pathogens and they eat our plants, but generally soil organisms eat organic matter and they eat each other. The whole biological system is driven by eating organic matter.

> ***Ray- The soil has got levels upon levels of organisms. Usually we think of big fish eating little fish and bigger fish eating the biggest fish and then maybe human beings catching it. The same thing is going on in the soil but it gets a little more complicated because the biochemistry is being carried out almost all by the microorganisms. The chemistry. But those microorganisms are being facilitated and given a home and moved around and the organic matter is being changed and they're working hand in hand with little critters.***

While soil organisms are chowing down, one of the most important things they do to benefit plants is make nutrients like nitrogen, phosphorus, and sulfur that were formerly bound up in organic matter available. You may wonder why this really matters if you're adding the nutrients your plants need in the form of fertilizers. The thing is, even when you add inorganic fertilizers to soil, plants still get much of the nitrogen they need from microbial nutrient cycling and organic matter decomposition. If you have more organic matter, you don't need as much fertilizer because the organisms are doing more of the work for you.

When I was talking about the physical effects of organic matter on water dynamics and soil aggregation, it may have seemed like organic matter is some inert substance, but clearly it isn't. It's the food source for soil organisms which cycle the nutrients that help plants grow.

I said at the start of this episode that I was going to answer the question of what organic matter does for your soil. So far, I've discussed the physical effects of organic matter on water dynamics and resistance to compaction, and the biological

role of organic matter in providing food for organisms that support plants. These two things lead to a bit of a paradox. The physical benefits rely on maintaining or increasing organic matter content. But the biological benefits rely on the decomposition or consumption of organic matter. In other words, to get the full benefits of organic matter, we simultaneously have to maintain or build it *and* consume it. This is really important, so let me say it again: to get the full benefits of organic matter, we simultaneously have to maintain or build it *and* consume it. Are these goals in opposition to each other? Is it possible to do both? Yes, it's possible, but historically we haven't been very good at it. That's why we have a lot of agricultural soils that are depleted in organic matter. But there are lots of innovative farmers leading the way in this area. We have some management strategies that we know work to build organic matter and increase productivity, but to implement these most effectively and to come up with more ideas, I think it helps to really understand the processes involved. This is why I will spend a few more episodes on organic matter. But wait, I'm not done with this one yet! I haven't yet talked about the effects of organic matter on soil chemical properties.

If you think of soil health as that three-legged stool of soil physical, biological, and chemical properties, organic matter is central to all three. I already talked about how organic matter influences the availability of nutrients like nitrogen, phosphorus and sulfur, but organic matter actually plays a role in the availability of other nutrients like calcium, magnesium, and potassium, too. These nutrients aren't cycled from organic matter in the same way as nitrogen, sulfur, and phosphorus. Instead, the way organic matter influences their availability is through its effects on cation exchange capacity, or CEC. You have probably noticed this value reported on a soil test before.

> ***Ray- An important chemical property of soils is cation exchange capacity. Cation exchange capacity is usually abbreviated as CEC. The very small particles in soisl have a lot of surface area because the particles are so small, and the surfaces have charges… both the minerals, mostly the clay, and the organic materia, the very finely broken up organic material that has a lot of charged sites as well. A lot of organic acids have charged sites.***

In a fairly neutral soil, they tend to be mostly negative charges, and that's why they attract positive charges.

Positively charged ions, you may recall from chemistry, are called cations.

Ray-Nutrients like calcium, magnesium, potassium, zinc, iron, manganese are all found in solution as positive cations. A calcium ion floating around in solution has two positive charges, a magnesium ion has two positive charges etc, etc. Instead of just washing out with the drainage water, the water moves through, but these ions are adsorbed because they're positive charges attracted to the negative charge on the clay and the organic matter. So it's a way the soil has of holding soluble ions that are quite available to plants, but doesn't let them leach away. If the soil does not have much capacity to hold these, the ions will leach away, and there will be very few nutrients for the plants to take up.

In the surface soil, where there's a lot of organic matter, often, more than half of the cation exchange capacity actually comes from the organic matter, not from the clay. So that's where we have more control. The amount of clay in a soil is pretty much a given, for a given soil. Organic matter, on the other hand, has a very high cation exchange capacity per unit weight. It usually doesn't comprise a very high percentage of the soil by weight, 1,2,3,4, maybe up to six or seven percent, but it has maybe ten to twenty times as much cation exchange capacity per unit weight. So if you have 20% clay and 2% organic matter, they may both contribute a similar amount to the cation exchange capacity. So you can see that by increasing the organic matter, you can increase the exchange capacity of the soil.

Something that might be striking you is that organic matter seems to do a lot of the same things as clay.

Ray-Chemically it acts much like clay but without the stickiness and difficulty of working. So you can get the advantages of having a high clay

> ***soil which are considerable in terms of holding water and holding nutrients without the disadvantages… anybody who has experienced clay first hand knows that it's nice to make pottery out of, but it's pretty miserable to have a lot of it in your soil.***

Okay, I think that's probably enough to chew on for the time being. We talked about the role of organic matter in water dynamics and soil aggregation, we talked about the role of organic matter as food for soil organisms that are responsible for cycling nutrients like nitrogen, sulfur, and phosphorus, and we also talked about the role of organic matter in holding onto other nutrients like calcium, potassium, and magnesium. It's pretty obvious that Johannes was right when he said that soil organic matter is the foundation of soil functioning. But how do we build organic matter so that we get the most benefit in terms of water and CEC while also encouraging soil organisms to break down organic matter so we get the benefits of nutrient cycling?

To get at that question, I'm going to spend next episode talking about where organic matter comes from. I hope you'll keep listening!

This podcast was made possible by a partnership grant from Northeast Sustainable Agriculture Research and Education. Please take the time to let us know what you think of this podcast so they can support (or not support, as the case may be) programs like this in the future. To provide feedback, please visit soilpodcast.com. I made that website super easy so you could remember it, so please do give me feedback! One more time-- soilpodcast.com. Okay, I think you've got it. Many thanks to Johannes Lehmann, Charlie White, Ivan Fernandez, and Ray Weil.