

## **Digging deeper: soil science, biodegradable mulches, and environmental sustainability with Markus Flury**

(00:00:00) Nataliya Shcherbatyuk

Hello and welcome to the Mulch Matters Podcast where we will explore the intriguing world of mulch and its impact on agriculture and the environment, as well as update you on the latest research about soil-biodegradable mulch and recycling options for plastic mulch. I am your host, Dr. Nataliya Shcherbatyuk, and I am a communications specialist for the project, "Improving end-of-life management of plastic mulch in strawberry system". In each episode, we'll dive into the latest research, trends, news, and insights on why mulch matters and how we can improve plastic mulch end-of-life options. We'll also branch out and discuss other plastics as well as talk to researchers, experts, and practitioners in the field who will share their insights and experiences on how to use mulch effectively in different settings.

(00:01:03) Nataliya Shcherbatyuk

Welcome back. In today's episode we welcome Markus Flurry, a leading expert in soil science with a deep passion for environmental sustainability. Markus is also a co-director of our end-of-life management of plastic mulch project and you heard from him back in the second episode, and if you did not please check it out. Markus will share his journey into soil science and his interest in optimizing soil resources for agriculture. We will dive into his extensive work with biodegradable mulches and discuss how soil science integrates physics, biology and chemistry to solve real world environmental challenges. So, sit back, relax and let's get started. Hi Markus, and welcome back. How are you today?

(00:02:01) Markus Flury

Very good. Hi, Nataliya. Thank you for having me back.

(00:02:05) Nataliya Shcherbatyuk

Of course. And, you know, I wanted to start by hearing a little bit about you and also how long have you been actually working with soil science and specifically biodegradable mulches?

(00:02:20) Markus Flury

I started working with soil science at the beginning of my graduate studies and that's what the area when Environmental science just became very popular and environmental issues became more and more mainstream in the public, and so I was getting interested in soils because I grew up in Switzerland where we don't have too many soil resources for agriculture.

So, I was interested in seeing how we can use soil for productive support of the population. So that's kind of how I started working in soil science. And it turned out to be very interesting because soil is a very complex system. So, you can apply many different things, you know, physics, biology, chemistry, and apply that to the relevant problems that we have in the environment and in society. So that's how I got started. And then that brings us to the biodegradable plastic. So that I started about maybe eight, eight years ago when I started to work with biodegradable plastics, plastic mulches in agriculture, and trying to apply my expertise in soil science to that new area of plastic mulches in agriculture.

(00:03:36) Nataliya Shcherbatyuk

Wow, that's fascinating. And you know, I like that you say that soils are very interesting and also very diverse. And I remember in Ukraine, where I'm coming from, we have a lot of soil what we call "Chernozem". And when I got here to Eastern Washington, all I could see it just sand. And it was so different at the same time, so fascinating just to learn about soils.

(00:04:02) Markus Flury

Yes. Yeah. Just as background information, you know, these "Chernozem" that you have in Ukraine and that we also have in the U.S. in the Midwest, they are the most fertile soils actually that we have on our planet. So, these are extremely valuable resources for agricultural production.

(00:04:20) Nataliya Shcherbatyuk

You know, now I'm thinking maybe I used to think that I have a green thumb. Maybe it's not about my green thumb. Maybe it's about the soil I always used in Ukraine. And you know, in today's conversation, I would really like to focus on actually how BDMs [soil biodegradable mulches] affect soil health. But before going to this question, could you actually tell our listeners what soil health is? Because, you know, we talk about soil health a lot and lately it seems to be a very hot topic, but actually soil health, what is it?

(00:05:00) Markus Flury

Yeah, soils are a living system. So, soils contain water, soil material and organisms. And all of those have a synergetic relationship with each other. So, soil is actually, you can almost call it an organism. You know, it's not a single organism, but it has an organism with many different living materials inside, like bacteria, you have fungi, you have earthworms and then you have mice and larger creatures that live in the soil together with their habitat, right? So, that's the soil matrix, the water and the air that's in there. So, you can consider the soil as an organism and as such, the organism can become sick, or it can be healthy in its initial state.

So, soil health is basically just expressing the health of that organism, what we call soil. And that can be assessed by measuring certain parameters like human health, right, or the human is also an organism that basically is comprised of our human body, but we also have microorganisms in our stomachs. So, all these have a synergistic relationship with each other and the same thing with soil. So, soil can, can become sick. They can be what we consider healthy. And so, soil scientists have come, come up with the term "soil health" to kind of assess the relationships between all those organisms, the inorganic material that we have in the soil and the relationship between those. So, this is basically what we call soil health. So how healthy a soil is, and usually we refer a soil, a healthy soil to the natural soil that we had initially, how it was formed, and then the health can deteriorate if we don't take care of it and kind of abuse it by using too many fertilizers or pesticides or destroying it by building stuff on top of the soil. So, these types of things, this is basically what we mean by soil health.

(00:07:04) Nataliya Shcherbatyuk

That's interesting. So basically, there are numerous communities that reside in the soil, and they basically reflect their health onto the soil health that we, scientists can measure that. Is that correct?

(00:07:20) Markus Flury

Yeah. That's right. Yeah. It's like human health, you know, human health. So, you have a tissue that can become inflamed for instance, right? So, and same thing with soil. So, a certain part of the soil structure can be compressed for instance, like if you drive on with a tractor and then you remove the pores, so like you get if you drive over a foot, for instance, you also get a compression on the foot. So, it's a similar concept.

(00:07:48) Nataliya Shcherbatyuk

And, you know, I'm thinking, so you mentioned that soil health is basically health of the soil in their natural stages. So now I'm thinking just because we have let's say, an area that we are looking at, and if the soil, if even the soil looks like it's healthy, but that's been influenced by us, it doesn't mean it's actually healthy. Or in other words, if the soil is healthy for certain crops, it doesn't mean it's going to be healthy for another crops. Does that make sense what I'm trying to say?

(00:08:26) Markus Flury

Yes, yeah, we can, of course, impact the soil health. Yeah, so, but normally healthy soil is just the state of the soil in its natural environment. So, if a soil grows in its natural environment, it's usually healthy soil. And that, of course, depends on where it is. You know, you mentioned you have these Chernozem soils in Ukraine. So, we would call it in the U.S. Mollisols. These soils in the natural states are very fertile

and have a high organic matter content. So, if they become kind of deteriorated by using too many fertilizers, or if you till too much, then the organic matter decreases, for instance, and then the soil becomes less healthy. So, in this case, you can, for instance, use organic matter as one of the indicators of soil health.

(00:09:17) Nataliya Shcherbatyuk

Okay, great. Thank you so much for the explanation. And going back to BDMs or biodegradable mulches, can we recall what biodegradable mulch is and how it's actually different from other plastics?

(00:09:33) Markus Flury

Yeah, so we use a lot of plastic mulches in agriculture for different types of agronomic benefits. Most of these plastic mulches are made out of polyethylene. It's a non-biodegradable material that is widely used as plastic and the problem with polyethylene is that it's oftentimes leaves some residues in the soil. So, you find the kind of plastic pieces that remain in the soil, and then you have issues also with disposal. So that's where the biodegradable plastics come in as an alternative, as a potentially useful substitute for the polyethylene mulches, because if they are biodegradable and you can till them into the soil then they would just degrade over time, and you wouldn't have all those negative aspects that are associated with polyethylene plastics.

(00:10:24) Nataliya Shcherbatyuk

And if you think about soil health and the concerning questions about soil health, what are the key benefits of using BDMs in agriculture practices?

(00:10:34) Markus Flury

Yeah, the benefit of biodegradable plastic is basically that it avoids the pollution of the soil with non-biodegradable plastics. So ultimately if you put plastic on the soil, it's something not natural, right? So that doesn't normally occur in nature. So, because if you have, for instance, plant residues that fall on the ground, they will decompose over time. And plastic that is remaining in the soil will not do that. They will just accumulate over time. So biodegradable plastic has the benefit that they would act like a natural residue that would fall onto the ground and then ultimately decay. So, it eliminates the pollution basically of soils with plastics.

(00:11:20) Nataliya Shcherbatyuk

Okay, that's interesting. And you know in the beginning you've been talking about these communities of the soil. There are a lot of different communities that live in the soil and we probably all

heard about microbial communities, so now in respect to microbial communities, how do these biodegradable mulches impact them, and their activities compared to traditional plastic mulches?

(00:11:49) Markus Flury

So, the biodegradable mulches impact the microorganisms in a way that the microorganisms actually are responsible for the biodegradation. So, the fungi and bacteria, they actually are the agents that are key in degrading materials that falls onto the ground organic matter as a general input that comes into the soil and BDMs are basically organic matters that they contain carbon and hydrogen and oxygen and the microorganisms that actually use those materials for their metabolism. So, the microorganisms actually act on the BDMs are a key component of biodegradation. In turn, the mulches will also impact the microorganisms probably also by kind of favoring certain microorganisms that can degrade the plastic mulches. But there is really not too much information, Nataliya, on how exactly microbial communities will shift over time. That also is in part because the carbon input that occurs by biodegradable mulches is relatively small compared to other carbon inputs from crop residues. So, from current studies that we know is that the impact, you know, the natural fluctuations to natural changes of microbial communities and community structure over the season is probably bigger than the impacts that we see from biodegradable plastic mulches themselves. So, there is a lot of variation. You know, if you measure microbial community in the spring, it's completely different than it will be in the fall. So, there is a natural fluctuation that is probably larger than the one that we would see from the input of biodegradable plastics.

(00:13:43) Nataliya Shcherbatyuk

Oh, that's interesting. Yeah. And you know, since we already started talking about research and studies, I also know you've done a lot of research with biodegradable mulch and obviously soil. Can you talk a bit about the effects of biodegradable mulches on soil nutrients, cycling and organic matter content?

(00:14:08) Markus Flury

So, the soils usually naturally recycle nutrients by plants take up nutrients, the nutrients go into the biomass, above biomass, and then normally they just fall back onto the soil. And so, you have a natural cycle of nutrients. Now, in agriculture, you take off the nutrients. above ground biomass and you remove the nutrients. So that's why we have to add back these nutrients that are lost. So, the main nutrients like phosphorus, nitrogen, and potassium. Now the question, how do those BDMs affect those nutrients? So, first of all, the BDMs, at least at the moment, we might maybe talk about that later on. The BDMs do not contain nutrients per se. The only thing that they contain is carbon. So, those microbes will use some of that carbon, of course, but they don't contain nitrogen or phosphorus or any other important nutrients that the plants would use. So, in this sense, there is little impact on the nutrient cycle of the biodegradable plastic. The organic matter input is also fairly small compared with other organic matter

inputs that we would have from plant residue. So, it's not a big impact there, but there are some indirect input effects that plastics have and plastics in general, whether it's viable or not, so that the plastic will change the microclimate of a soil. So, one of the benefits of those plastics is that they increase temperatures of the soil that helps plants to germinate a little bit earlier to grow faster. They also help to increase the soil moisture content, particularly in semi-arid regions. And those indirect impacts on temperature and water, they will, of course, then also impact the soil nutrient cycling and organic matter content. But so far, most of the research has shown that usually organic matter content starts to increase with the use of plastic, whether it's biodegradable or polyethylene. So that usually makes an increase in organic matter content and also helps to conserve some of the water and prevents leaching potentially. So, there are some positive benefits whether it's biodegradable or not on the nutrient cycling.

(00:16:25) Nataliya Shcherbatyuk

And extend more on the biodegradable mulches from the research perspective, are there any long-term studies that actually were looking at biodegradable mulches and how they affect soil structure and erosion control?

(00:16:42) Markus Flury

Yes, there are more and more studies now done with the BDMs, not too many. We don't really have very long-term studies, you know, probably nothing more than 20 years. So, we don't have too too many long-term studies like in ecosystem studies where we have going back 50, 60 years. So that we don't have yet, but these studies are now, and since BDMs become more and more popular, so these studies are now set up and people look at the long-term impacts on soil structure and also soil erosion as we go. I think there are some studies in Europe that have been probably over 10 or 15 years and then we are starting to do more and more long-term studies. But there are certainly not a lot of long-term studies and not detailed studies, you know, on soil structure or on plastic residues that would remain in the soil over the long term. So, this is still a research need that we are addressing, and the scientific community is working on that.

(00:17:45) Nataliya Shcherbatyuk

And, you know, as a scientist and researcher, I really like to hear that more research is needed. I know we want to have answers, and we want to have answers now, but when scientist is speaking in me, it's like, oh yes, there are still so many questions to answer. It means we still have so much work to do. So, that's exciting part of, you know, it's a good that there are long-term studies, and they show us some results and a lot of information, but it's also exciting that there are still a lot to investigate and learn more about biodegradable mulch impact on soil overall. And talking about biodegradable mulches, what are some potential drawbacks or challenges which are associated with the use of BDMs in agriculture?

(00:18:40) Markus Flury

Some of the important drawbacks is that we still don't know exactly how well those particle mulches will degrade and how fast they will degrade in different soils. So, every soil is different, and every climate will differently affect the degradation of biodegradable plastic. So generally, biodegradation is favored if you have a lot of moisture and have higher temperatures. So, from this, you can extrapolate that the biodegradable plastic will better degrade in a warm climate like Florida, for instance, as compared to a colder climate like Minnesota or something or Washington. So, we need to still understand how well those plastics actually degrade, how long it takes to degrade; and another issue is also the concern that the plastics will degrade in smaller and smaller fractions, what we call micro(nano)plastics, and we still need to make sure that these micro(nano)plastics fully degrade and be able to quantify that degradation and verify that this is indeed happening. The research that we have so far is promising and shows that this probably will happen, but we still have to do a lot of work to just confirm these concerns that oftentimes are raised by certain people about the use and potential threats that can come out from biodegradable plastics.

(00:20:10) Nataliya Shcherbatyuk

Yeah, that's interesting. Yeah. And Markus, are there any advancements in biodegradable mulch technology that you would like to share with our audience? And how might these advancements actually more improve soil health and sustainability in agriculture?

(00:20:33) Markus Flury

Yeah, I think we have a lot of opportunities, you know, to improve the current BDM technology of these plastics. So, at the moment, the plastics are mainly made out of carbon, oxygen and hydrogen, and then some additives that are added to the plastics. But I think there are probably a lot of opportunities to also add some enzymes or add nutrients, for instance, or even pesticides into the plastics that would help actually for the for the plant production so that you wouldn't have to apply any pesticides or nutrients afterwards. And then I think a key thing, and I've just heard recently that people are working on those issues that they try to formulate some enzymes or solutions that could be incorporated into the plastics themselves that would help the degradation and facilitate the speed of degradation of those environmental products of these biodegradable plastics when they are tilled into the soil. So, there are activities going on at the moment to kind of improve the degradation and the use of bio plastic technology.

(00:21:48) Nataliya Shcherbatyuk

Hmm. That's really interesting. And you know, I'm learning today a lot as well. I didn't know about this part and that sounds pretty promising from the perspective of, you know, laying biodegradable

mulches for some strategies might be challenging because there are some soil-borne diseases that they need to take control of first. So, they are probably working on improving this question as well. That's interesting.

(00:22:20) Markus Flury

There could be some synergistic things, you know, there is also a lot of work being done these days with nanotechnology in agriculture where you use nanoparticles as pesticides to control diseases in the soil so plant diseases and that could be potentially incorporated into a biodegradable plastic and then that material could be released and then have some economic benefits in the future.

(00:22:50) Nataliya Shcherbatyuk

So, we definitely need to follow up with the research for the next few years ahead. And stepping back from biodegradable mulches, I would like to ask you what I would say a fun question because you know, it kind of will make you think a little bit outside the box. What do you find the most fascinating and the most, I know you touched that a little bit in the beginning, but there is anything else you would like to add for our audience and maybe even got somebody interested in soil and soil science.

(00:23:28) Markus Flury

Yeah, I think the most fascinating thing about soil is that soils are really the foundation of civilizations. If you look at the history of humans, you know, we work with the soil, we use the soil, started to cultivate it and basically our civilizations are supported by soil. And so, this is just by itself a very interesting and complex story as we do, for instance, these planetary explorations, you know, on Mars, we are trying to see if there's anything similar to soil, because this is the first part that will support life. And as we go to exoplanets and see whether there are civilizations on other planets, Planetary systems, and the question is always, is there a soil that would support those civilizations over the long term? Basically, our human civilization has only been able to survive because of the unique system that we call soil that basically feeds us. So that's a fascinating thing, the overall arching interest in soil and then to study the intricacies about the physics, chemistry, and biology is, that's what's a really fascinating part of working with soils in general.

(00:24:44) Nataliya Shcherbatyuk

I have to agree with you 100%. I always like to say that everything starts from the soil. And you know, lately I was reading about horticultural therapy, it's, you know, how plants might affect our health, wellbeing, mood and all of that. And there are actually studies that show if you play with the soil or basically do the gardening, the aroma comes out from the soil affecting our moods. Isn't that true?

(00:25:14) Markus Flury

It's fascinating. Yeah.

(00:25:18) Nataliya Shcherbatyuk

Yeah. It's nature. Well, Markus, thank you so much for the great discussion. I hope that our audience has learned a lot and definitely I will be inviting you back to our podcast.

(00:25:32) Markus Flury

Nataliya, it was a pleasure to talk to you.

(00:25:34) Nataliya Shcherbatyuk

Thank you

(00:25:34) Markus Flury

Thank you so much for having me.

(00:25:37) Nataliya Shcherbatyuk

That's it for today and until the next episode. You can find more information by following us on Instagram and LinkedIn by @mulch\_matters and going to our websites [www.smallfruits.wsu.edu](http://www.smallfruits.wsu.edu) and choose mulch technologies. This work is supported by Specialty Crops Research Initiative Award 2022-51181-38325 from the USDA National Institute of Food and Agriculture. Any opinions, findings, conclusions, or recommendations expressed on this podcast are those of the author(s) and do not necessarily reflect the view of the U.S. Department of Agriculture.

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