Plastic Pollution in Agriculture: Challenges, Solutions, and the Global Impact with Dr. Karen Mancl

[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.

[00:01:04] Nataliya Shcherbatyuk:

Welcome back to you podcast. Today we're excited to have Dr. Karen Mancl, a professor from Ohio state university. Karen brings experience in plastic pollution, sustainability, and international environmental policies. Let's dive in. Hi, Karen, how are you?

[00:01:25] Karen Mancl:

Hey, I am well.

[00:01:27] Nataliya Shcherbatyuk:

Oh, this is great. Thank you so much for joining us. Karen, can you share a little bit about your background and actually what inspired you to focus on plastic pollution and sustainability in agriculture?

[00:01:42] Karen Mancl:

Uh, so I am a professor of Food, Agricultural and Biological Engineering at the Ohio State University, and I am also a fellow with the Woodrow Wilson Center for international scholars in Washington DC. So, I kind of wear two hats. So, my technical area is actually in wastewater treatment, and we use plastic in wastewater. But my work that I do with the Wilson Center is on rural environmental issues in both the United States and China. And a big issue in both countries is plastic and plastic pollution. So, that's how I started to get involved with plastic was working more in my international policy work.

[00:02:39] Nataliya Shcherbatyuk:

That's interesting. So, let's talk a little bit more about China and plastic. How has China's push to increase agricultural production led to a rise of plastic use? And how does this compare with agricultural practices here in the United States?

[00:02:58] Karen Mancl:

Okay, so we need to go back in history a little bit, and one of the things that's really useful is to kind of get a background in Chinese agriculture compared to US agriculture, and you can see why plastic is so important to Chinese agriculture. So, the United States and China are both about the same size, so the land area of the two countries is about the same size. But the population of the two countries is very different. The United States has a population of about one third of a billion people, where China has a population of 1. 4 billion people. So, in the same land area, they have, you know, multiple times more people, right? So, you know, agricultural production is extremely important to feed all those extra people.

So, when you look at farms in the United States and you look at farms in China, an average farm size in the United States is about 444 acres, the average farm size in China is 1. 6 acres. So that 1. 6 acres, you have to support your family and you're, you know, all, if you're a farmer, you have to support your, you know, your livelihood on only 1.6 acres. Now, when looking at the amount of land that's available to grow food, comparing the United States and China. In the United States we have close to five hundred, five thousand square meters of agricultural land per person. So, thinking about it this way, that's about the size of a football field. So, all the food that would be grown to feed you, each individual. You have about a football field's worth of area to grow it. But in China, they have so many more people there, they have less than a thousand square meters per person to grow their food. That's about the size of two basketball courts. So, it's extremely important to get the most you can out of that small land area in order to feed the people in the country and also to support your family.

So, the emphasis on yield and getting the most out of a small area really began in about the 1970s or so, when the population of China was growing close to a billion people. And what was quite remarkable is that China was able to feed themselves. The Chinese were able to feed themselves, feed a billion people on their agricultural land that they had been farming for thousands of years. We've only been farming in the United States for, you know, two to three hundred years. Where they've been farming for, you know, several thousand years. And, you know, we're able to grow enough food to feed that many people. So, the reason why the 1970s are so important is that's when our agricultural scientists really first started to go to China to learn more about Chinese agriculture. And Chinese agricultural scientists were coming to the United States to learn more about American agriculture. There was an agricultural exchange that was negotiated between our two governments in order to learn more about each other. And one of the first things that our American agricultural scientists learned when they went to China was, they saw China using plastic to enhance their

agricultural production and brought back sketches and brought back descriptions of how they were using plastic in agriculture to increase agricultural production. So, in the 80s, it really took off in the 80s, the Chinese started to use more and more agricultural plastic in order to warm the soil in order to conserve water in order to reduce. Pests and weeds and all of the benefits gain all the benefits that you know, your listeners already know about using agricultural plastic. So, they started to use it in a big way.

Right now, China is the biggest user of agricultural plastic on the planet, 90% of the greenhouses, plastic greenhouses on planet Earth are in China. And also 75% of the mulch that's used in the world is also used in China. So, you could carpet the entire state of Nebraska with the agricultural mulch that they're using in China.

[00:08:06] Nataliya Shcherbatyuk:

Wow. Never thought about that. That's interesting. That's a lot. And, you know, speaking about the use of plastic mulches and not only mulches, but also different agricultural plastic in China and in United States, could you talk a little bit about what environmental consequences that we can look at?

[00:08:33] Karen Mancl:

Well, agricultural plastic, as I said, really started to take off in the 1980s in China. And they've been using it continuously since then. Now, one of the things that's different about the use of agricultural mulches in the United States versus China is its thickness. In the United States, we tend to use much thicker plastic. So, it's easier to, you know, collect it and roll it up at the end of the growing season. Where in China, the agricultural plastic mulch that they use is very thin, about the thickness of, you know, almost like plastic wrap, very, very thin. So thin, that it's impossible to pick up that it just, it would just break apart by the end of the growing season.

So, what do they do? They just plow it in, they just plow it into the soil. And they've been doing that since the 1980s continuously. They just put down another very, very thin sheet of agricultural plastic and they plant their crops. And then the plastic starts to fall apart by the end of the growing season. They plow it in again, and they've been doing that for decades. So now, the amount of plastic in their soil is really becoming significant. It's significant in terms of it being, you know, litter. It gets caught on the agricultural equipment, it blows with the wind, gets trapped, caught on fence, gets incorporated into the bales of the, you know, the cotton and whatever else they're harvesting and contaminating the crop. This plastic is just everywhere because they've just been plowing it into the soil. And now it's gotten to the point that there's so much, there's so many plastic particles in the soil that it's starting to impact the physical properties of the soil. It's also starting to change the physical properties of the soils and affecting the movement of air and water and other materials through the soil. So, you know, we don't have this problem. That's not a big problem yet in the United States, so we can really look to another country to see, you know, what's happened and also how they're dealing with it.

[00:11:02] Nataliya Shcherbatyuk:

Yeah, and lately you actually hear a lot about microplastic or fragments, plastic fragments. So, it is definitely an increasing concern. And you mentioned about fragments or microplastics impact on the soil, soil health. Can you talk a bit about how they can also impact crop productivity?

[00:11:24] Karen Mancl:

So, it's just, just beginning, you know, the micro, you know, the oceans have gotten so much attention. Everybody's concerned about plastic getting into the ocean, but 23 times more microplastics are in soil than are in the ocean. So, we have, you know, a very big concern with all of these agricultural plastics being, you know, trapped in the soil, right now, the biggest impact that the Chinese are seeing, they're way ahead of the United States in terms of doing research on this. So, their research has been mostly on the changes to the physical properties of the soil, but now the research is starting to show there's beginning to be some other impacts on, you know, chemicals, chemical movement, chemicals absorbed onto these plastic particles, and also uptake into the plant itself. Some of these plastics moving into the plant itself. So that research is just beginning, but the most striking research has been mostly on the impact the plastics have had on the soil itself.

[00:12:39] Nataliya Shcherbatyuk:

Yeah, that's. Wow. And what steps are being taken to reduce plastic fragment in agricultural field and you mentioned that, for example, in United States, plastics are thicker. So, can that help out with the ripping and leaving the fragments, and is there anything else that is being done to reduce plastic?

[00:13:05] Karen Mancl:

Well, there are really five strategies that, you know, that farmers and governments can use to reduce, uh, plastic, uh, impact. On agriculture and the soil. And one of those strategies is called extender produce extended producer responsibility. I don't know if you've ever heard of that. That's where the manufacturers of the plastic are responsible for it. So even after they sell it, they're responsible for it. So they are really the only country that's really taken a leadership role on extended producer responsibility when it comes to plastic mulch is Ireland. So, you know, when you sell agricultural plastic in Ireland, you're responsible for it. So there are, you know, all types of programs and incentives to make sure that that plastic gets collected and properly recycled or disposed of, uh, and it's driven by the producer of the plastic. So, you know, this is one particular strategy.

Another strategy is to ban burning of plastic, because a lot of the plastic that's, that's used in the field, because it's so dirty, and because it's starting to, you know, come apart after all that exposure to UV light, the plastic starts to deteriorate. It's really difficult to handle. And difficult to recycle. So, a lot of it is just collected and burned in the field. Well, that sends those particles then into the atmosphere that come back down onto the soil as dry fall. So, banning open burning most of the programs that most of the policies about burning tend to be local. So that's one of the things you'll see in the United States

that there might be a county ban on open burning, or in the countryside, there might be, you know, even at the state level, but this tends to be more of a local policy, and it's more from the air pollution type of strategy.

Another strategy in order to reduce contamination from plastic is to improve the quality of the plastic and make sure that you're able to recycle it. So, one of the things is, you know, making sure that the plastic is thick enough that you can collect it. And that's been the first thing that the Chinese have done. They have really recently but, I don't have the date written down here. They've recently established a ban on the very, very, very thin plastic. And so, you can't even sell it anymore. So, so all of the agricultural plastics must be here. It is 2019, they had in 2000. They passed a plastics order that the minimum thickness of agricultural plastic that can be sold in China is 10 microns, where before it was down to, you know, four microns. Very, very, very thin. Now, by American standards, that's still pretty thin, but it enables them to collect it. This plastic at the end of the growing season, and then you know, can either be properly disposed of or recycled. So that was a step that the Chinese have already taken in order to set standards on the thickness of the of the plastic to enable them to collect it.

A fourth strategy is requiring collection that if you put agricultural mulch out there, you're required to collect it and turn it back in, so to speak. So, I'm not aware of any countries that are doing that yet that are requiring collection. There might be some at the local level, but I'm not aware of any national level requirements.

And then the 5th strategy would be to incentivize farmers to collect, you know, have a, you know, like we have that for plastic bottles, for example, with a deposit, you know, you pay a deposit when you buy it and then you get that money back when you turn it in. But having some kind of, I don't know, an incentive to make sure that this plastic mulch is collected and properly disposed of and not just plowed back into the soil.

So those are the five strategies. That, you know, are out there and the Chinese are focusing really on the plastic quality, making sure that the plastic is thicker so that they can collect it.

[00:17:53] Nataliya Shcherbatyuk:

Yeah, this is this is very interesting. And I'd like to expand more a little bit about, back to China and how is China addressing agricultural plastic waste compared to United States? And you mentioned that thickness is one of that. Is there anything else that we can add to it? And also what are the lessons that we can learn from both countries on this question?

[00:18:21] Karen Mancl:

So, you know, they support quite a bit of research on agricultural plastic from everything ranging from, you know, its uses to enhance agriculture and enhance yield. A lot of the research that I've been

looking at is, you know, in using agricultural plastic on crops we would never even bother with in the United States. They use agricultural plastic to grow cotton in western China. So, in order to conserve moisture and to warm up the soil. So, they're using agricultural plastic for, you know, row crops, they're using it for rice, they're using it for all types of, you know, field crops that we would have never even have dreamed of using it for in the United States. So that's one area where you see a lot of research coming out of China. The other thing is they're doing a lot of research on the impacts on the soil, because they have so much more plastic in the soil. So that's what I was quoting, talking about before. That really that they're seeing the biggest impacts now on the physical properties. And now they're just beginning to start to see some biological impacts and chemical impacts of having all of this plastic in the soil. But even that the research is still mixed in some places, it shows that it's. detrimental in other places. It shows there's no impact. And in a third, you know, research paper, you'll see that there might even be an enhancement, because of absorption of nutrients or something.

So, you know, you're, that research is still, you know, all over the board, but there's a lot of it going on in the Chinese agricultural academies, but the area that's really exciting right now that's going on both in the United States and in Europe and in China is biodegradable plastic. So, and, you know, all of the research, I know that that's being done at, you know, your university, that's being done at other universities in the United States, looking at biodegradable plastic. And that research is very, very encouraging.

[00:20:36] Nataliya Shcherbatyuk:

Yes. And while we are on the topic of biodegradable plastics, I'd like to expand on this question as well. So, biodegradable plastics, it does seem like a quite promising solution, but would you mind telling a little bit about benefits and drawbacks of using biodegradable mulch in agriculture?

[00:20:58] Karen Mancl:

So, using biodegradable plastic mulch, you know, has the big benefit of not having to collect it, not having to pull it. So, you know, that's probably the biggest impact that it's just plowed in, you know, kind of like they have been doing with the non- biodegradable plastic for decades and decades. This material, you know, in order to be classified as biodegradable must degrade in the soil over a two-year period. So, by, you know, by plowing it back into the soil, it will degrade. So that's the exciting part in terms of ease of use and not having to collect it. So that reduces the labor, and it reduces the effort of trying to collect it. But it's there. It's not equivalent. Biodegradable plastics are not equivalent to the PE plastics that have been the traditional agricultural plastics that have been used. A lot of people point to the cost. They're more expensive. But, you know, I'm looking at, you know, my history when I bought my first calculator, how expensive it was. And now, you know, they're, you know, they're like in breakfast cereal, you can get a free calculator, you know, whatever. So, with more use and development, and if a country like China were to require the use of biodegradable plastics with its huge market. That would definitely impact the price. So, I don't see it as it's obstacle in terms of the

speed of adoption, but I don't think it's an insurmountable obstacle, but the other ones that are still of concern are things like biodegradable plastic is not quite as strong as the traditional plastic mulches. So it could be, you have to be really careful when you put it into the field because it can tear. So, it's not quite as strong. There's a lot of good work going on improving the strength of the plastic. So that's, you know, could change into the future. But that's one of the big concerns.

Also, because it breaks down in the field. It's designed to break down in the field, you know, as it's in use, it's starting to break down to make sure that you get gain the benefits before it breaks down too much that, you know, matching that up is going to, you know, breaks down over a 2- year period. You know, making sure that you gain the benefits before it starts to deteriorate. Also, it turns out that biodegradable plastic is not as effective at water retention as the traditional plastic mulches are, that water can move through it more easily, water vapor can move through it more easily. And also, it's not as effective at warming the soil as traditional plastics. So, some of those benefits.

And then one of the last things you always have to consider is, what if it isn't incorporated into the soil? What if it starts to break apart and blow away? In the air and in the water. It doesn't degrade. It's biodegradable in soil. It's biodegradable in like compost. So, if it were collected and put into compost, it was put into an anaerobic digester, then it would decompose. But if it blows away, or if it washes away, so it's in the air, it's in the water, those environments, it's not degradable in those environments. So, it doesn't solve 100% of the issues that we have with plastic blowing away or washing away.

[00:24:58] Nataliya Shcherbatyuk:

Do you know about any studies who are actually doing this work about plastic being blown away or washed away?

[00:25:05] Karen Mancl:

Like I said, my colleagues in China, it's amazing how much they publish on these things.

[00:25:12] Nataliya Shcherbatyuk:

That's really interesting. You know, I never thought about that, yes, it's biodegradable in the soil, but how about if it's not in the soil environment, what's going to be after that?

[00:25:23] Karen Mancl:

I know that's a big concern with the biodegradable plastic bags and, you know, other biodegradable plastics that are on the consumer market. You know, if you just throw it in the trash and you put it into a landfill, it's probably not going to degrade. It needs to be either incorporated into the soil. or incorporated into a composting, you know, environment where there's active microorganisms breaking it down. So, you know, we have the same issues with, you know, biodegradable plastics that are used for consumer products as well.

[00:25:55] Nataliya Shcherbatyuk:

Interesting. But definitely we should have instruction on the bags, what to do after we use them. And you know, biodegradable mulch is definitely raised in the conversations. And, you know, several of our previous episodes, we spoke a lot about policies and regulations, and especially for biodegradable mulches in organic agriculture. And now I'm wondering, if we talk about regulations and policies about these biodegradable plastic mulches, what is the difference between those policies when we speak for United States and China? Is there any similarity or any difference how they approach that, including conventional and including organic, if possible?

[00:26:42] Karen Mancl:

Well, right now, organic is it's not allowing the use of Ag, biodegradable plastic mulch. It doesn't meet their criteria. So, you know, that that's the same everywhere. If, you know, if you have, you know, these types of labeling restrictions, the biggest concerns that I have is in standards for biodegradable models, standards for biodegradable plastic mulch. The Chinese were the first to come up with a standard. They published their standards for biodegradable plastic mulch in 2017, and that was quickly followed by the European Union. They published their standard in 2018. So, but labeling that this material is biodegradable and has been tested and meets these international standards is going to be really important to any grower, even if they were to change the restrictions, lift the restrictions on organic, you have to make sure that you have, you know, the proper material and you're using it properly. So labeling and standard setting, that's an area where we need a lot of work in the policy space in order to make sure that the materials that are being sold, used in the field meet, are tested and meet the standards and that they, that we have the capability to properly handle them. Mm

[00:28:21] Nataliya Shcherbatyuk:

I see. And let's switch a little bit out from biodegradable plastic mulch. And let me ask you, what do you think are the most promising strategies for reducing plastic waste in agriculture? And a little bit more on how important do you think that US and China collaborations? well?

[00:28:54] Karen Mancl:

In those solutions are in terms of thinking the whole through the whole life cycle, in terms of being, you know, putting down mulch that doesn't deteriorate to the point that you can't pick it up and then once you are able to pick it up. That there is, there is a recycling program for it, that's going to take a lot of work. Every time I've found, as I've looked around, especially in the United States, you know, an area where they were collecting, you know, silage bags, or they were collecting, you know, flower pots, or, you know, different types of agricultural plastics, I'd find a reference to it and then I'd go and I'd track it down and they don't do that anymore because it's just there's there wasn't any market for it or, you know, labor costs were getting too high. It's really, really expensive to recycle this material and without, you know, government support, both as carrots and as sticks. It's not going to happen on its own. The market forces there to collect and recycle. Agricultural mulch. So, there's going to need to

be some policies, both in terms of incentives and in penalties, in order to make sure that we, you know, because the use of agricultural plastics, especially in China, where the pressure is so high to keep their yields up in order to feed their big population, they're not going to abandon it. They're going to continue to use agricultural plastic for the foreseeable future. The United States, you know, we're the land of plenty, we have more food than we, you know, that, than we need in our country. That's why we export some, so much food. If we were to reduce the use of agricultural plastic in the United States, it wouldn't Impact us, our food supply negatively. It might change some seasonality of it and might change some availability of it, but overall we're going to have plenty to eat. In China, that's not the case. They need to be using every tool in their toolbox to keep their productivity up. And agricultural plastics is one of those tools. So, um, so without, you know, carrots and sticks, without, you know, Incentives and penalties, the collection and recycling of this material isn't going to happen.

[00:31:32] Nataliya Shcherbatyuk:

And what about us, talking to us as a consumer, what do you think, how can we contribute to reducing the impact of plastic pollution in agriculture?

[00:31:43] Karen Mancl:

Oh, that's a really good one. Well, the packaging part of it is also a significant part, you know, the plastic clamshells that are berries come in the plastic mesh bags that are oranges come in and our potatoes come in, you know, a lot of that isn't recyclable. A lot of recycling programs won't accept those types of materials, even though there might be a label on their claiming that they're recyclable. So, you know, using either having reusable, containers or bags, encouraging that in order to bring our produce home, or, you know, packaging in paper, which is recycled, which is compostable, you know, that those are the areas I think where we're going to have the biggest impact as consumers. That's interesting. It's in the packaging. It's in that packaging part of that white pollution.

[00:32:55] Nataliya Shcherbatyuk:

Yeah. And I like to look at the, you know, that label of the packaging, what do they say about usually just the sign of recycling or not, but they don't really say, what do you do? Where do you take it? If you want to throw it away somewhere like. What's the details? What's the instruction?

[00:33:09] Karen Mancl:

So up until recently, our recycling program in central Ohio would not accept the clamshells, you know, if you put them in the recycling, they just got pulled out and hauled to landfill, but they just changed that within the last couple of months where now they've got some kind of a market for them. So now they said, you know, you can actually put those, those, you know, plastic cherry tomatoes and containers. I can actually put those now in my recycling, but that's not everywhere in Washington, DC. area. They won't accept it. So, it's not universal yet. So, even though the, the container might say it's recyclable, the local recycler can't recycle it. It just ends up getting separated out and taken to landfill.

[00:34:04] Nataliya Shcherbatyuk:

Yeah, and separation, I'm sure it just complicates the whole recycling process just to pull it out.

[00:34:14] Karen Mancl:

The other thing is, we can do as consumers: I grew up the daughter of a grocer. You know, I grew up in the grocery, in the grocery business, and, you know, I'm old enough now that I remember there were certain seasons of the year that you couldn't get certain fruits and vegetables that, you know, you didn't eat you know, lettuce salad in February. And you know, there were certain seasons of the year that you ate apples, and you ate, you know, all of these different, you know, there was a certain time of the year when the oranges were in season and that's when you would eat them and the rest of the year. Well, then you just didn't have them. You just had processed oranges like orange juice or whatever. So, you know, maybe this demand to have. Everything available, all year round, you know, that creates all these plastic shipping containers, the Styrofoam, the plastic bags in order to, you know, move all these products around and, maybe we need to, as consumers start to rethink our menus and think back more to eating what's in season locally instead of depending upon things being shipped from great distances and all the plastic packaging that goes into it.

[00:35:44] Nataliya Shcherbatyuk:

I do agree with that well first because I'm coming from Ukraine and we really eat by the season because you know that we see what's the garden and what's the local market is and from the nutrition perspective, eating the seasonal food, it's even healthier than eating something which is not like you say it's been harvested somewhere so it takes time to move it around so definitely nutrition values is decreasing for that as well. And tell us a little bit about what is your favorite project or success story in your work on plastic pollution? And also, what is your secret? How do you stay motivated in the face of environmental challenges?

[00:36:29] Karen Mancl:

Well, this all started, believe it or not, my journey down this whole plastic waste and agriculture was just starting to work with the Wilson Center of this think tank in Washington, DC. And they were really concerned about ocean plastic. So, I was, you know, new to the group, so I was sitting in on these meetings just to listen and take notes and see how I could contribute. And I was listening to all these people talking about plastic grocery bags and plastic straws and plastic cups and plastic bottles and all that focus and me being in agriculture. I'm sitting there and I just very innocently said to them, but what about agricultural plastic? And everyone turned and looked at me like I was crazy. What are you talking about, agricultural plastic? So, I quickly, you know, found some statistics on my computer to share with them. And when I looked into China, it just, it even surprised me. I knew that the Chinese used a lot of agricultural plastics, but the amount was, was even surprising to me. And that just opened that opened doors in our, in our efforts to educate and influence policymakers about, you know, environmental issues between the United States and China. When you brought in the whole

idea that we also need to think about agricultural plastics that all the hot and glamorous and, you know, headline grabbing things about plastics on beaches and plastics in the ocean was nothing compared to plastics in the soil and the volumes of agricultural plastics that, you know, there's 23 times more plastic in the soil than there is in the ocean is I think something that earlier. So, that really got me started on this. Probably the biggest reward that I've gained is the people that I've gotten to know. And especially the Chinese researchers, because this was during the pandemic when I started down this, this journey to learn more, more about the environmental impacts of this issue in both the United States and China.

So, I reached out to some Chinese researchers online had never met him, you know, it was like I said, during the pandemic, it was during, you know, these, this time when the relationship from the United States and China was not very strong and because of my the history of my work in China and my reputation, I got a I got a response and a very enthusiastic response that they were very excited that to know that there was a prestigious American researcher who was interested in their work, and it just opened so many doors for me. I've gotten to go to China to meet them. I've actually been able to write with them and coauthor with them and, you know, attributing the, both the US and the Chinese perspective and the US and Chinese policy perspective to these papers. And that's been really a big reward, so, you know, looking into the future, we have so much to learn from each other. And it's been very discouraging to see so many obstacles put in the way for Chinese and US researchers to collaborate and work together when we've done so successively for 40 years, for 40 years, US and Chinese agricultural experts have traveled back and forth and collaborated. And it's opened the doors for both countries and to see those doors closing Very, very discouraging and very sad.

[00:40:43] Nataliya Shcherbatyuk:

Yeah. Well, Karen, thank you so much for being with us today and sharing your knowledge. It's been a pleasure. Thank you so much.

[00:40:51] Karen Mancl:

It’s been a pleasure.

[00:40:55] 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 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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