Is Organic Worth It? Organic vs Conventional Farming & Its Role In Human Health - Dr. Andrew Smith Transcript

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Podcast Introduction

Welcome to Dive into Health MD, the podcast where we explore how everyday habits shape your physical, cognitive and financial well-being. Through conversations with physicians, scientists and farmers, we explored how daily choices like food, movement, sleep and mindset shape the health and life we experience with special episodes on sourcing high quality food ingredients.

We do our best to stay up to date and we're always open to refining our thinking as new knowledge emerges. I'm your host, Dr. Akshita Mehta. Let's dive in.

I'm so excited to chat. So, Dr. Andrew Smith, thanks so much for talking with us today. For listeners who may not know the Rodale Institute, can you start by explaining what the Institute is and what its mission is in your role?

Sure. I am the Chief Scientific Officer at Rodal Institute. The Rodel Institute started in 1947. as a research institute, really focused on organic agriculture.

The founder, J. I. Rodeo, he was really on a journey to understand, you know, when he founded the institute he said soil equals healthy food equals, healthy people.

because he was on a journey to understand how you grew food to ultimately lead to human health. He wasn't a farmer, he actually was an industrialist. Him and his brother were manufacturing switches, and they suddenly found themselves with a little bit of wealth, so he bought a farm.

Rodale Institute Mission and History

And when he asked people how to grow food, because it wasn' a farmers, we said, I'm going to buy this farm, it was a run down dilapidated farm that they restored and regenerated, that's where some of these words started to get into the vernacular.

And people said, well, here's how you grow. Here's what how modern farmers grow food. We use these chemicals that we use, these synthetic fertilizers.

This was in the late thirties, forties right around, you know, coming out of the end of world war two. And they were saying, we have these stores of nitrogen fertilizer with great to grow crops.

You can increase yields. we had these. Chemicals that were essentially tear gas that. Where we used to kill people, but we can use it in a kill insects, now you don't have to worry about insects anymore, you have the word disease, we can grow much higher yields.

And he said, this doesn't make sense to me. I don' understand how I take something that's a poison and toxic, I put it into the soil, put into it the environment, and then it turns me and my family, that we become healthier.

That doesn' make any sense. The response was, it's not about health, It's about production. We want to produce as much as we possibly can per acre. has nothing to do with health, but that didn't sit well with him.

So it sent him on an inquiry and he said, well, there's nobody doing any research in this. Nobody wanted to take his money to research. We started his own research organization.

He also started writing what led to a magazine called Organic Farming and Gardening. That was really where the word organic started to become popularized in the English vernacular for natural farming or farming without chemicals.

Then his son, Bob Rodale, And even as the family now, Maria Rodale is still actively involved with the Rodeo Institute, who's J. I.' 's granddaughter. We're really champions of the organic movement.

They were talking with government saying we need a program. There's no investment from our government in organic agriculture. So that's the beginning of of The Rodio Institute today.

our 400 acre campus in Kutztown, Pennsylvania. So about an hour, two hours from New York City, hour and a half from Philadelphia. And we do research on organic agriculture.

We have an education program to educate the next generation of farmers. Um, and we have consulting that meets with farmers to help them transition to organic work or just make any changes to their farm that they think are kind of on that continuum towards a more natural organic farming model.

Amazing. Thank you. There's so much work that has come out of the Rodale Institute. I'm really excited to get into it and to chat about everything you guys are doing and everything that you found over the last many decades.

But just to backtrack a little bit, you've spent your career studying agriculture. I come from medicine and specifically as a radiologist. What do you wish physicians understood about farming and the modern food system?

So I was actually hired to start the vegetable systems trial, which hopefully we'll talk a little bit about and I started. thinking about that healthy soil equals healthy food equals to healthy people, right?

And so I guess as a physician, as doctor, if I said to you or ask you the question, does food improve health? You know, what people eat? Does their diet impact health.

I assume you'd say yes. And there might be nuances there. There might arguments about what are the pillars of health and what food is better. But for the most part, you would agree that the food you eat impacts human health, But if I said to you, does soil impact health?

You would probably glaze over, in most physicians glaze, over like, what does the soil have to do with anything? But all the food, 90, I think 95 to 99% of all of the foods we eat is grown in the soils.

Things like fish that are not grown on the soles, but most of our food that we start in our soil. So if the our foods that eat starts with our soils and the things we ate impacts health, soil should impact human health.

And that's really the inquiry that we're on and part of the really just extension of inquiry, that J. I. Rodale started back in the 1940s. Amazing. So the burning question that I usually get is about organic farming, right?

And is it worth it? Is there really a difference between organic versus conventional farming? And tying in your comments about soil, one of the studies that you guys did was the farming systems trial that began in the early 80s and ran for several decades and looking at soil specifically and then differences in outcomes.

Can you walk us through that a little bit? 1980 USDA published a report that was mostly based on the subscription of the organic gardening and farming magazine from Rodale.

So they did a survey and they actually went across the country and visited farms that were, you know, claiming to grow naturally without chemicals and they basically said, wow, we're surprised.

There's a lot of farms out here that are grown without. And they're pretty productive and it's not just your small scale backyard farm. Some of them are Hundreds of acres some of them are thousands of Acres and they said we should do more research and the government should invest more into organic farming and so in 1981 Bob Rodale

started the farming systems trial was really called the I think was called The conversion trial at first it was intended to go just for a few years to see what happens to soil when it moves from a degraded conventional system.

Why Soil Health Matters for Human Health

And we knew that this plot of land that they had purchased right next to the Institute was heavily degrading through tillage and chemical practices and track that over time and see the change in the soil health.

After a few years, they just kept going. It exists today. I believe it's in its 46th year. And there's been other trials similar to it. There's trials, there was one in the USDA Beltsville in Maryland, Iowa State, University of Wisconsin, California, one even before this in Switzerland.

And so several countries, India has a couple of long-term trials now, and they pretty much all say the same thing or show the the soil health improves, largely the increase of carbon.

We often say organic matter, but people understand carbon now. Soil scientists have been talking about soil carbon for decades, people are starting to understand that there's this carbon cycle and we have too much of it in the atmosphere, we need to put more of back in soil.

But most soil-health indicators, there are hundreds you can measure, are positively correlated with So that's probably one of the biggest findings, that we increase soil carbon in the soil.

We increase so carbon deeper in soil, so we're storing more carbon, deeper, in this soil and that results in things like greater water holding capacity.

So during periods of drought, we have more moisture in a soil so, you tend to have higher yields in your organic system during the periods or drought or low rainfall.

It helps the structure, it's the food for microbes, right, and the glue that exudes from microbes and from plant roots creates a structure that holds the soil together.

So when it does rain, more of the water infiltrates into the soils and less of it runs off. When water runs of of off the field, it usually carries not only soil, but if we're talking about a conventional system, its usually carrying herbicides, insecticides and fungicides.

and synthetic nitrogen into our streams, which will eventually run downstream into estuaries and like the Gulf of Mexico, the Chesapeake Bay, creating dead zones.

And so in our goal to produce as much food as possible, we're actually degrading our environment and decreasing our ability, decreasing part of our food source through industrial agriculture.

Yeah, amazing. There were so much that you touched on there. Really kind of getting into the history of where did some of this start. We talked about like the Green Revolution a little bit.

The goal during that time was we have this growing population. How do we feed more and more people? And there were all sorts of decisions that went into that.

Cultural practices that came out of that, one of which was the use of these pesticides and herbicides. Through the uses of those and also other practices like tilling, and seed selection and all sorts of things, we've seen change in the outcome of the food that's produced.

A big part, as you're mentioning, is the soil health that has declined over time through these particular agricultural practices. And we're able to see with organic and then regenerative organic practices that hopefully we'll talk about as well, a return of that soil-health and how that-soil health then translates into The nutrient density of the food and yeah, so so many other things that you mentioned the ecological sustainability impact of all of these things, right?

Healthy soils have that ability to sequester carbon out of atmosphere and to hold on to more of that water. within the soils that we don't see as much runoff and we do not see much of these environmental toxins getting into our waterways and our systems through all of the other means.

So organic is a lot more than just the lack of pesticide use, but has a much bigger ecologic and climate-related impact. Why should a physician care about the soil and care the climate?

And I think the answer that you're saying is it all translates into what we eat, and that has to do with our health. You have so many things to touch on there.

I'm going to hit on a few things and I apologize if you've hit these in other podcasts. So you mentioned the Green Revolution. It increased our ability to produce food largely through breeding and so we're able to increase yields.

which reduced food insecurity and, of course, that was on a smaller set of crops.

Organic Farming, Soil Carbon, and Nutrient Density

So over time, we've produced more food per acre, more calories per acres, but we also probably restricted our diet in that we're not eating traditional foods across the globe.

And it's led to something that I don't think was anticipated at the beginning, which was what we call hidden hunger. Through crop breeding, mostly, we've increased starch and carbohydrate content of our food, and many of the minerals, vitamins, amino acids have declined for different reasons through our crop-breeding, crop selection.

And so hidden hunger is basically like you have achieved your caloric intake, your needs, but you are deficient in other nutrients. So that's What we call hidden hunger and that's part of where we're looking at is our inquiry is why is the nutritional content of the food.

Decrease we know the crop reading is one of factors. We look at we didn't I don't think we anticipated climate change either, but we are finding. that increase of carbon dioxide, partly for some of the same mechanisms as increases of fertilizer.

So increased fertilizer can tend to dilute nutrients, increase carbon-dioxide in the atmosphere. Our crops will grow more, but it dilutes these nutrients.

You know, they can, as I say, per acre or per hectare, the plant takes up the amount of minerals, what is diluted across the crop. And then when we eat it, you know we ate the carbohydrates and starch.

We're getting less of those critical nutrients. And if you look at vegetables, for example, we're actually breeding vegetables one to have higher water content.

So we tend to see that that's another change is that there's higher moisture in our vegetables. Um, and we are breeding them to be hard as a rock so that they can ship, you know, thousands of miles.

But rarely are we breeding those crops for taste or for nutritional quality. And then in parallel to all that, you know, since the beginning of the Green Revolution, almost all the global reports show degradation of soil.

And that's where Rodale came in, because we basically said to ourselves, okay, we see the nutritional quality of food is declining. We see this decline in health, especially in non-communicable diseases.

Is that related to food and nutrition? This decline of nutrition. of global soil degradation, but all of our data, like we talked about the farming systems trial, shows that if we transition or switch to an organic method or practices, we actually improve the soil.

So that's where we started asking the question, what if, if what we had a massive switch globally to organic

farming, could we restore the nutritional quality of our food through the way we farm.

And, you know, we, I think there's two touch points from a human health perspective. One is the chemicals in our bodies and chemicals and our environment, and the other is, are the concentrations of the nutrients.

Yeah, exactly. What's in it and then what's not in. Those are things that we need to talk about when it comes to really all food products, right? Um, so, when we talk growing food, one of questions is what is grown and You're talking about seed selection and how that's been a part of our history that we're selecting for specific varieties for several different One is transportation time.

We have become accustomed to wanting the same foods in our grocery stores 365 days a year for a lot of things. And that can lead to really long transportation times or, you know, certain foods that just don't grow in your area.

Maybe they grow on the other coast. It takes a little while to ship them and we want that food to stay intact. So that was one piece of it. Then the thing that you mentioned was the varietals that we're selecting for are also bigger.

So something that has been talked about is the dilution effect of choosing these bigger varieties. And you're saying that we have the caloric density there.

We might be eating food and that it has a certain amount of calories that could help with satiety, but the nutrient profile is not equivalent to where it used to be in the past with older varieties.

But something that I don't fully understand is how significant is that nutrient decline? So I think Dr. Donald Davis had a paper looking at the nutrient and decline in foods from the 1950s to, you know, 99 and did show varying nutrient declines.

Do you have a sense of how significantly that those declimes are? Are we talking, a little bit of decline and as long as we're eating a well-balanced diet should be okay?

Or is it more severe than that? Well, I just happen to have a presentation that I am giving up, so it helps. And I've looked at Dr. Davis's paper, some papers that did similar work in the UK, and then other papers, that we're looking more at grains.

Those papers are more fruits and vegetables. So you're the doctor, I'm not the doctors. So, you probably would prescribe a diverse diet, eat your rainbow to get that diverse fruits and vegetables.

But just to look at the declines here, and I've taken the averages, so it's from multiple publications, but calcium is down between 20 and 45%. Copper, 70%. Zinc, 59%. Iron, 30%. Magnesium, 40%. Potassium, 50%. Riboflavin, 15%. Protein in general, because it can be so variable, is anywhere between 5% to 50% decline.

I think barley, for example, showed a 50 percent decline in total protein. And then you look at essential amino acids, and so there's different amino acid that might be critical that are declined.

And we've actually have a little bit of data now from our research that's showing, you know, how you grow a food, like whether you till the soil more or less, or whether use synthetic fertilizers versus organic fertilisers, might not change the total protein, but it might actually change, the amino acid profile.

And so that is interesting to know that how we grow our food is, because in this case, we're doing it on the same field, on same soil, under the environmental conditions, and the, same variety of crop.

So the only thing that differs is how, So that gives you a sense and maybe as a doctor, you have more of a since of what that means from a population health perspective, but certainly some of those minerals that I mentioned in protein, especially globally, populations are deficient in and they might be especially deficien or have problems in pregnant women, for example, or people that have disorders.

So I think it's pretty significant. If we've shifted the way we grow our food, And then we say we have 70% copper decline. So anyway, so that gives you a sense of…

And I would also say that I'm looking at the years. And these are from 2003, 2006, 1995. I don't recall any publication within the last 10 or even maybe even close to 20 years that has redone or taken another look at the nutritional decline of our foods.

Where we are right now, I don't know. It could be much more severe than that. Interesting. Thanks. Those numbers are helpful to get a sense of, you know, what are we talking about?

Is it just an insignificant amount of decline or is there something real? And so what's the solution there? Do we know that organic or regenerative organic farming, can that bring things back to where it used to be?

Crop Breeding, Hidden Hunger, and Nutrient Decline

Or are seeing, any positive benefit of farming from organic and regenerative organic matter. Yeah. So let me start a little bit of how, you know, we got to where we are because when that paper came out by Dr.

Davis, I think the first one was 2003, 2004, then another one in 2009. We were asking the question that I mentioned earlier, is it has something to do with the soil?

And so we looked and we said, well, let's look at organic. Let's just take a look and organic versus conventional, because if organic soils, you know, everywhere we look tend to be improved, then we should see an increase in.

nutritional concentrations in organic and lo and behold, we saw that several reports and some of them pretty robust meta-analyses showed increased nutritional content inorganic.

But the scientific community pushed back and said, well, you can't really say that it's because of the way they were grown because what I call took a market basket approach.

You just went to the store, you picked apples off the shelf. And how do you know it's not because apples in New Zealand are healthier than apples, in, New York state?

Maybe it is because of where you chose them from or where we grow. organic in different soils because it's easier to grow there. So there's all these other factors that weren't controlled for environmental factors.

And then there was some other research that John Reginald looked at strawberries and he did it in one county in California where they're really only growing two varieties of strawberries.

All the strawberries get planted within You know, a week or two of each other, so you can really control a better control for environment, better, control, for soil type.

And lo and behold, he found some significant differences, increased microbial activity in the soil, increase phytonutrient or antioxidant activity and organic.

organic crops. And that was probably one of the first studies that actually started to look at the soil in nutritional concentrations and nutritional quality.

Most of them were just taking things off the shelf and testing them. Amazing that, you know, we can actually test for these things, right, and see the effects directly in relation to the Do we have an idea of where the soil versus the seed selection plays into that effect?

My understanding, and tell me if I'm wrong, is part of the seeds selection with certain wheat varieties, for example, we selected for dwarf varieties first of all, but then we are seeing, I think, more quantities or proportions of the endosperm compared to the germ in the bran where most of nutrients rely.

And then seeing that in other crops as well, I think you alluded to earlier, there's more starch in there, right? There's much more carbs and fewer amounts of other nutrients.

So does seed selection pay as much of a role or is it mostly soil or some kind of combination of those? Well, I think they all play a role, and I, think, time will tell.

We probably need a little more time to be able to statistically analyze what's playing a greater role. Clearly, crop selection, seed selection and genetics is a major role and there's starting to some progress in development for nutritional quality and sometimes coinciding with selection for flavor and probably those two go hand-in-hand and there's probably a negative correlation between things like storability, you know, ability to ship.

I don't know. Yeah, so what you have a little bit is let's just take your tomato, if you grow heirloom or heritage variety tomato you like it because it tastes better, it probably has higher lycopene content or different phytonutrients, but it's not going to ship well.

Sometimes it doesn't even make it from the farm to the farmers market before cracking. So that's a struggle for farmers. It has to look good, especially for produce.

There's this strong aesthetic look that you have to meet, market. What I didn't mention was that we started the vegetable systems trial in 2016, which is a side-by-side comparison of conventional organic vegetable production to try to control even more for some of those factors.

You know, like we talked about, we grow them in the county, they have similar soils, but we're now growing produce or vegetables on the exact same soil under the same environmental conditions, the are being used, we are starting to expand a little bit and saying, okay, We've grown one variety of squash and we're seeing some differences between organic and conventional.

Well, what if we grew three or four different varieties of Squash? And then we can start to see, you know, how important is how they're grown versus the variety?

So that is something that we've started to look at. And the other thing is what's hard about that question, to be honest, if you took, let's just say three varieties wheat and you grew them, in multiple locations across the country, which isn't always that easy because different wheat varieties don't grow so great in different parts of the county.

They're more localized or regionalized. But if you did that for two or three years, you'd have a pretty good sense of which one has higher nutritional quality.

If you do that in the study that I just mentioned, sometimes two to three year isn t enough to give you a significant difference. When I go back in literature, there were some early studies that that said, okay, let's use compost versus synthetic fertilizer for three years.

Very rarely did they actually study a piece of land that was managed organically for a long period of time versus land managed conventionally for long periods of times.

But if you ask soil scientists, how long does it take for the soil to change, to have a measurable change from a practice? It's usually a minimum of five years, so if we're trying to answer the question how important is soil, you need at least five years to start to see a difference in the soil.

Environment matters, so some years it's sunny, low rainfall, other years you get it cloudy and you have heavier rainfall. That changes the nutritional concentration as well.

So some of these early studies that did two or three years of a different practice tended not to a see difference. And then they reported it doesn't really matter, organic versus conventional doesn' t really matters.

Or synthetic fertilizer versus natural fertilizer doesn t matter. There was a study done at the Tagassic, which is an

Irish research station, where they were looking at phytonutrients.

And the one paper that I was familiar with looked at cursitin and onion, and I believe they looked it over nine years.

Organic vs Conventional Nutrient Comparisons

If they had stopped the trial, it's year six. there would have been no significant difference. But after nine years, there was significant different. So it's a little bit more difficult to answer that question about how important is soil because the soil changes over time.

And then what happens if you are you've been an organic farmer for 30 or 40 years? How this soil could be continued to improve? And so that's why we intend to have these long-term trials to be able to understand that.

But I will say that I'm analyzing the first eight years of our trial. This I've analyzed but haven't published yet. So we're growing potatoes, green beans, butternut squash, sweet corn, and lettuce.

of diversity of vegetables that we're growing. You know, like potatoes, I think, is the most consumed vegetable. It's a root crop. Lettuce is highly consumed.

We have fruit crops like squash and sweet corn. Generally, across all those vegetables, after eight years, we are seeing significant increases in boron, zinc, copper, sulfur, potassium, and nitrogen, which in this case could just be crude protein, in the organic compared to the conventional.

And there's iron and phosphorus are marginally significant. So we expect that over time those will manifest themselves. I think having that eight years of data, we're able to actually start to see significant differences that we can report scientifically.

Incredible. Are you measuring differences between, I guess, regenerative organic farming and conventional organic farm? And maybe this is a good time to even define what that means.

Yeah. So it's a little bit of a controversy in the industry, because Bob Rodale was the one who coined the word regenerate or popularized it. Where I see it the first time was from Sir Albert Howard, which a lot of people talk about as Some people say the godfather of organic because he was studying compost, but he used the word ecological regenerative agriculture in some of his writing.

But anyway, so the world regenerated to some extent started with the Rodeo Institute, But it's become popularized to mean a lot of things. And, and honestly, there's no real real label Rodale Institute along with Dr.

Bronner's and Patagonia started a regenerate organic label. It's regenerating organic certification starts with organic. You must be. certified organic, you have to be certified, organic and then it adds on top of soil health, more stringent soil, health practices and principles.

It adds animal welfare and social fairness. So I don't want to get too much into that, but there's a lot of labels out there that are regenerative, but they're not organic.

And I think it is confusing about what does the word regenerate mean. I look at as regenerated as a scale or a continuum, right? That we're moving towards regenerating, or we are moving away from regenerator, which would be degenerative.

So in both of our farming systems trial, which I mentioned earlier, and our vegetable systems trials, we do have a full tillage component and we have reduced tilling component that we would probably call more on the regenerative end.

And that's in conventional and organic. And where I struggle with the term regenerative but not organic, or separating the words regenerate and organic is we didn't talk about pesticides and chemicals in the environment.

But in our research, we find that when we add no-till, so we reduce tillage, which most people call regenerated practice, reducing tilled, We have to increase herbicide use, and we have increase synthetic fertilizer use.

And when do that, We increase weed resistance. So weed resistances, we have weeds that are no longer killed by herbicides. The way to overcome that is we increase the rate of herbicide.

We spray different herbicides like atrazine, metallochlor, 2,4-D, chemicals that known endocrine disruptors, known carcinogens. in order to ensure a so-called regenerative practice.

And we're putting those, you know, the nitrogen that we put in goes into our groundwater, or it goes in to our environment as nitrous oxide, a greenhouse gas.

Those chemicals go into the streams and waters and we drink, and they make people sick. Nowhere do we think you can use the word regenerate and separate it from health, right?

The conversation is about health. If you say, I'm a regenerative farmer, because I do no-till, but the chemicals I use make people sick, we don't see how that could be regenerated.

And farming communities and the scientific community has more and more compelling evidence that these chemicals are truly making people's sick. Maybe especially more population epidemiological studies are showing that areas where literally you can you can say, this is what crops are grown.

And so because these are the crops that are growing, these other chemicals that I used, and these were the cancers that were going to be here. So we can just slowly go back to the food that we grow and it's all associated back with the chemicals.

We know that areas have more fruits and vegetables, have higher leukemia and lymphoma, in areas where grain crops have colorectal colon cancer and all cancer types.

So anyway, so I get off my soapbox, but yeah, we are looking at what we would call regenerative practices and even the organic, regenerate organic. Part of our research separate from this nutritional testing at Rodale is how do we effectively do reduce tillage or practices, and still maintain high productivity.

Yeah, interesting. Are there different pesticides that we use on wheat products that are that where we're seeing different types of cancers like colorectal cancers compared to fruits and vegetables?

Yeah, I don't have the data right in front of me, but there's a great paper by Gherkin et al. I think it was either end of 2024. And then I can't even keep up with it.

An email every week of different health impacts of the different cancers or different disorders. But you look at something like neonicotinoid seed treatment.

It's pesticide. It's on 90% of the seeds that get planted as a coating. It is highly water-soluble. There is more and more evidence that it is associated with Parkinson's disease.

Seed Selection, Variety, and Long-Term Trials

In a study of only 300 people, 299 of them had neonicotinoids in their spinal column fluid. And in some cases, they had more than one neonicotinoid compound.

And agronomic studies have shown that this compound is actually, not only is it not providing improved economic benefits to farmers, it actually disrupts soil ecology and might actually lead to worse outcomes or needs for more pesticides.

It's banned. have an impact in bee health, honeybee health and other pollinator health. So for that reason, the

European Union has mostly banned it. But in the United States, probably 90% of our field crop seeds are coated with it to the point where it's now, because we coat it with seeds, we use more of it on a total acre of poundage than we did when we just sprayed the chemicals.

when we saw the insect on the crop. Yeah, there's so much to think about there. I mean, people talk about glyphosate, right? Roundup is also what it's known as, and that's the one that has been talked about the most, but there are so many other compounds that probably have varying effects.

that are all, you know, are prevalent in our food system as well. And so lots of research. Yeah, I guess the biggest part of the big issue with glyphosate, especially with you mentioned wheat or small grains is spraying it as a desiccant.

So now you're spraying just before harvest. That can happen in things like potatoes. and dry beans as well. Okay, yeah, I was familiar with that with wheat and beans and no potatoes.

It was used as a deskin for potatoes aswell. That's super interesting. The other comment that I get when it comes to organic farming is that pesticides are still able to be used.

Can you talk about the differences between pesticides that are used in conventional farming versus organic Yeah, we'll start again from the start with a more balanced or integrated approach for pest management.

Not only for pests, but even for fertility, you really need to have a good crop rotation, meaning that you're growing multiple crops in a sequence with each other.

If you look at like just grain crops, for example, the majority of farmers across the country that are growing are going corn. And they sometimes grow soybeans, and you can't do that organically.

You're going to get pest problems. Your cost for fertility is going be too high. So when we work with farmers, we're usually a minimum of three different crops in a sequence, but four to six.

And some farmers have eight to 12 different props they grow. especially if they have a diversified vegetable farm, and they do that in a way that prevents or mitigates disease so they don't even have to spray at all.

So we know that crop rotation can almost eliminate the need for chemicals. The chemicals that they are using, or I shouldn't say the chemicals, the products, in some cases are biological.

So it could be releasing natural enemies like parasitoid wasps that actually attack caterpillars and things that are pests. In some cases, farmers are managing their environment where they're encouraging these natural entities to exist and live.

And we actually know that as we stop spraying insecticides, we get a lot more of these national enemies and suddenly we don't need to manage the pests anymore.

But then when farmers chemicals, I don't even know if they're chemicals. They might be things like copper or sulfur. So these are naturally occurring.

And in many cases here in the Northeast United States, soils are becoming deficient in sulfur, so spraying sulfur for disease might not be a terrible thing.

What's the word I'm looking for? True, the word's not coming to me, but basically the life of the chemical in the environment. When I grew strawberries, I sprayed hydrogen peroxide for gray mold.

Hydrogen perooxide, once it evaporates, is gone. So you can go back in that field in a couple hours, probably. Where other compounds that are conventional, in some cases, they're so persistent.

The persistence in environment is years. In some case, When we look at chemical residues in organic versus conventional, the only chemicals we're finding on the organic are things like lindane and DDT that have been banned for decades, but they're still persistent in the environments.

Most of the things that are sprayed on organic or used in inorganic agriculture have very low persistence, hours or days in environment. Yeah. Okay. Yeah, so the half life of some of us and pesticides could be significantly longer years or decades, it sounds like.

And so, yeah, I mean, when we talked about wheat and potatoes and grains, pesticides being used on those products as a desk and being sprayed immediately before harvest, common sense says the dose exposure there is significantly higher, right?

And that's the harm. When seeds, which are very early on, obviously, in the growing season, right at the beginning, when those are coated, is the risk that that pesticide then gets released into the environment and we see downstream health effects from that?

Or is there residues on the produce that's grown from the seed or the product that is grown in that seed? Yeah, I would say that, well, and it might depend on what you're eating.

So the things that are applied, let's say, you know, this time, right now it's May, we're planting and if those things are on the crop right, now, especially if there are grains that aren't going to get harvested till October, November, it is very unlikely that those are going create residues on crops.

And then if you are talking about things like even wheat, that gets processed before it gets to you, or it get fed to animals, But that neonicotinoid is what is called a systemic insecticide.

It goes inside the plant and it provides long-term protection. So I do have concern with root crops like carrots and potatoes that they'll say, well, it's below the the risk, the levels of these pesticides are below the risks, but I don't know if we really know what that risk level is, and you're not saying it's zero.

But if you get organic, they're allowed in organic so you know it is zero, so that was when I started farming and understood the use of systemic insecticides and especially on root crops, I really warned people and said, eat, you have to choose something.

potatoes and carrots and root crops, choose those organic because these are being taken up by the root expressed in the plant.

Regenerative Organic Farming and Tillage

And it goes back to persistence. The whole point of it is that they maintain the insecticidal properties for weeks or months. So the goal of using those chemicals is persistence, So yeah, so those are the things that concern me.

Probably there's some concern with what's in milk and what the animals are eating. And I don't know, I'm not sure how strong the regulations are around what is being fed to animals and then what gets translated and gets transitioned or that's the word I am looking for I guess.

It's like excreted into the… Yeah, it gets to humans, right? Yeah. Are the seeds that people buy at like a Home Depot or something for backyard gardening, are those seeds coated with similar products or is this all for like professional, you know, like agricultural farmers?

Usually no. I mean, they usually are pink or blue. But, I was at a conference and the farmers didn't even know where you could purchase seeds that weren't coated.

And if you want the seeds not coated, you'd have to tell the companies in advance and probably pay a fee. So you have the pay extra not to get something as opposed to getting it.

But in the organic, it's illegal. You're not allowed to use those. Organic farmers, when they source their seed, they're always untreated. so you know that they aren't coming in with organic.

I think what we didn' talk about, but the impact of the farm worker, because they know to put on protective clothing when they put chemicals out of a jug and put it into the back of the sprayer.

But it's not normal for them to load seed, to, you know, put a face mask and wear protective clothes when you're just putting your seed into your bin.

And I think that there's pretty heavy contamination when the seeds are coated in the farm worker population. Yeah, I talked to someone who actually got an interest in human health and food.

In her background, she was a sociologist and her PhD was in migrant farmer workers. And we're seeing the significant health effects that were arising in these populations in relation to their exposure and lack of protective clothing.

while working in these. So I think that just goes to show some of the research and I'm not fully well versed in this when it comes to toxicity in relation to pesticides.

Some of it is maybe looking at it in isolation, but what we really need to look at is cumulative dose response. If you look one carrot, for example, and we just talk about the toxicity of that one product, I that's a different scenario than someone who has a carrot plus leafy greens plus cucumbers plus tomatoes and all these things in one dish and then I think the dose exposure gets significantly higher.

And I'm not sure that we have correlative data that explains that. But that's helpful to know that root vegetables can have a higher dose. I usually tell people if you're going to choose something organic, go for wheat.

um, or grains because the dose I'm assuming is higher, you know, being sprayed right before harvest, but I'll add root vegetables to that recommendation.

And I, and I be honest, I mean, wasn't completely basing that on science. You know? I was based on watching how things are grown and seeing the chemicals and know what the chemical do.

My recommendation 20 years ago was root, vegetables, dairy. and at that time, it wasn' so obvious that the small grains and wheat were And I don't know back then if they round up or glyphosate was being used as a desiccant.

This might be a newer phenomenon. Newer application. Yeah. I dunno what the history is there. Something that you touched on as well was tillage. Can you explain why that matters?

You know, too much disturbs the soil and that can impact, it can negatively impact soil health. And actually we have a lot of data and, you know it really started, we had the dust bowl and during the great depression in the thirties and it started what's now the NRCS, the Soil Conservation Service.

That led to conservation practices to reduce erosion. As herbicides came onto the market, the same way in Rodeo, but, you know, agriculture said, wait, one way we can mitigate tillage or increase tilled and soil erosion, both from wind and rain is having not having the soil exposed to those environments.

So we don't till them. Unfortunately, that's one conservation practice. When we work with a farmer to transition, or you look at most organic farmers, They need green manure.

So green manures are plants that are grown specifically to improve fertility. These are like clovers, vetch, even a good crop rotation can provide the source of fertility, they often grow maybe perennial crops, like maybe it's used for hay so that it keeps the soil covered.

They often are using natural fertilizers like compost. So they're putting carbon back in the soil as well as fertility.

Natural fertilisers actually have not as hard on the soils, so to speak.

Don't impact soil health as hardest synthetic fertiliser. They also grow a crop rotation. When you grow things like small grains like wheat, then where we are in Pennsylvania at least, you plant the wheat in fall and now you have a constant cover all winter.

My point is, what our finding is is that when you only do no-till, you don't add cover crops or green manures, You don' add natural fertilizers or what I call carbon fertilisers, like manure and compost.

You actually, it's worse for the soil. All of our long-term, we have now, since 2008, in our farming systems trial, We have continuous no till and we organic with tillage and organic reduced till, It's not complete elimination of till.

And the complete continuous no-till has the worst soil health. And part of that is, if you think about it, we're growing mostly corn every year. Those corn stalks sit on the surface.

How do we get the carbon into the soil? Most of those cornstalks just sit in the soil until they eventually degrade, become carbon dioxide, and go into environment.

But in an organic system we use what I would call smart tillage. We're plowing those crop residues into soil. We're growing thousands of pounds of plant biomass as green manures and cover crops that we're putting into the soil.

We are feeding microbes and the mechanism for carbon storage in the soils is increasing microbial biomass and that life-death cycle increases soil carbon.

And we can actually put those sources of carbon and fertility deeper in the soil, and that ultimately leads to improved soil health. So, you know, to simply say no till is the answer, it's really much more complex and complicated than just simply saying not tilling.

We should be reducing tillage with a suite of conservation practices, soil conservation, practices. Interesting. Is green manure cover cropping? Does that mean the same thing?

It does, but I would say there's some difference. Most farmers are putting cover crops down to cover the soil as a way to mitigate erosion or to capture the nitrogen that they put down or their fertilizer they've put them.

But organic farmers, are using it typically as source of fertility. So it's much more intentional. For example, just to give you one example. We grow oats.

One of the benefits of us growing oats is that we can broadcast clover into it. When we harvest the oats, we have this thick clove, and we let that grow through the fall.

And next year we could do grow a number of crops. So when we plow that into the soil, it's a tremendous amount of nitrogen for the next crop. That's our source of Nitrogen.

We didn't have to buy it from a bag, get it in a bad. It's way cheaper, especially than any organic source, of that we would get. And if you do that for decades, along with the fertility, the nitrogen that's in that clover, there's also carbon and there is also food for the microbes and that little by little leads to improved soil.

So I look at green manure as a little bit different if your intentionally using it to build the fertile of the soil or you're simply using as an erosion mitigation That clover eventually will get mixed in essentially with the top layers of the soil and then that's what allows for that nitrogen and carbon to enter that system.

Yeah, in that case it will because clover is pretty hard to kill without some tillage. So some of the areas where we're trying to work are things like, could you use a flame leader to killed it?

Pesticides, Seed Treatments, and Exposure Risks

Could you used electric to kills it. But clove has a pretty strong root, so a lot of times you can kill the top, but you don't kill it, it just grows back.

But we use biology for something like vetch. Vetch is a high nitrogen producer that will kill or will die because it's a winter annual. So once it goes into the reproductive phase, it wants to put all of its energy into grain, and then die.

So in that case, we might plant directly into vetch or we may plant into cereal rye and use that as a weed suppressing mulch. And now we have the benefit of the soil erosion.

We have a benefit from the fertility. If it's done right, then we had the benefits of reduced passes over the field, so lower labor, lower fuel costs, but it is more challenging from a perspective.

So there's the areas of where we need to continue to increase research. Okay. And what is the benefit or difference of getting nitrogen from a clover crop versus a synthetic input other than cost?

That's great. Because that goes back to cover crops. We're actually finding that just simply planting a cover crop like cereal rye, which is a high carbon, you would think that from the soil carbon perspective, we grow ryes, carbon biomass, it actually results in starving the soil of carbon because you need some nitrogen.

So nitrogen is food, is protein, right? It's, you know, in amino acids, its protein. so it's a much higher quality food for the soy microbes. What happens often in conventional, You increase synthetic nitrogen to overcome that carbon, what we call nitrogen tie up from the carbon.

It can, if done well, either form of nitrogen can lead to improved soil carbon and nutrient cycling. Typically, farmers are concerned about putting down enough nitrogen.

So they tend to over apply or double the amount. And that often leads to an overuse of nitrogen, I'm not sure if I completely answered your question. Yeah, no, yeah, the question was, you know, is using cover cropping or clover, for example, as a source of Nitrogen, Is there a benefit to that over a synthetic nitrogen product?

And maybe the answer was for overusing the synthetic nitrogen product, then we get issues into entrance into the water system. Essentially. Yeah, that's that.

That's an impact and you and it's better because. It's coming with carbon. Right, so it's coming with all the carbons in plants where most of the synthetic fertilizers are termed inorganic.

So in organic meaning no carbon, not carbon based. You're not putting any carbon back in the soil. That's what I mentioned earlier, it takes five years to see a change.

If you just use carbon one year and you say, oh, I didn't see it change in soil health, but if you use it for five, 10, 15 years, you're adding more carbon into the Yeah, interesting.

So we've been talking obviously a lot about soil health and why that matters and how that translates into what's actually grown. Can we get a little bit more into the details of what is actually happening in this soil?

How is it so different than a conventional? Yes, and if we get back to nutritional quality too, because that's an area that is really of interest to ours, is looking at the soil microbial ecology and how that impacts nutritional equality.

So mostly when we, from a soil-microbial perspective, we don't necessarily see a difference like more bacteria or more fungi in organic, They'll, you know, ecology will fill the niche, I mean, if you spray a side which kills things and it kills the bacteria, other bacterias will flourish and they'll fill that niche.

You do tend to see a greater diversity of microbes in organic soils compared to conventional soils. A recent study that we did also shows their functional ecology is different.

So the microbes that are in the organic are recyclers, so they're taking things like clover and they are recycling and making the nitrogen available, or they might even be nitrogen fixers.

They're actually taking atmospheric nitrogen and turning it into a form that the plants can use. In the conventional, they actually tend to be parasitic from a fertilizer perspective, meaning they feed on free-living nitrogen.

So they're actually stealing it from the crop. There's a completely separate functional diversity based on how you grow the crops. And what we've been looking at a little bit is how that impacts nutrition.

We've had this one compound called ergothionein. I don't know if you've heard of ergathione before or not. Yeah, this is one of my questions for you, so I'm glad that you're bringing it up.

Well, when we talked to some scientists, and these are scientists in the medical community at Penn State Hershey Medical Center, we said we're trying to link soil health to human health.

They said, We think we have your link because ergothionein is only produced by fungi and mycobacteria or fungi-like bacteria in this soil. So they have different families of bacteria that produce ergothynein.

But we find it in food. We know that plants can't make it. Actually, a paper came out Recently, that there are some plant families that have retained the ability to synthesize.

But they're rare, they are rare plants, but anyway, so we're obtaining it from our diet from the food that we eat and. The medical community is an active area of research in the medical communities because it continues to be linked to as an antioxidant, anti-inflammatory, long-term, large cohort studies show those individuals that have higher levels of ergothione in their blood have reduced heart disease, and this is almost every heart diseases like, you know, strokes, all-course mortality, cardiovascular disease.

You know that better than I do. It looks like it might mitigate neurodegenerative diseases, like Alzheimer's and Parkinson's. So anyway, it's a very active area of research in the medical community.

It looks like, everywhere you look, more ergothione better. So our question is, how do you, I mean, maybe how you biophortify that in food? Or how we use practices that are going to boost it in a food.

that reducing tillage actually increases ergothionein. And so we actually do see high levels of it, even in our conventional no-till. We know that when we till, we disrupt fungal communities, and we can increase fungo biomass by tilling because we put all that food, that green manure in the soil.

So we create the food for fungi to eat, but we're disrupting the fungi that creates symbiosis with the plant. So there's something called mycorrhizal fungi or a buscular mycohrysofungi.

They actually associate with a plant, they have part of their, like they inject themselves into the plants. And they can scavenge for moisture, scavange for phosphorus and nutrients.

so they're a benefit to the plan and the planet actually feeds them. One interesting thing though in the We know that we actually stopped using phosphorus fertilizer, but we were actually finding that, we had, were using phosphorous fertilizer in the conventional system, so the plant didn't need phosphorus.

So it didn' reward the mycorrhizal fungi, and the micro rhizofungi went away.

Cover Crops, Green Manure, and Soil Microbes

And then all of the synthetic phosphorus, because it was a synthetic form that was soluble in water, went away. Suddenly the plant was deficient in phosphorus in the organic system where we are not actually in this case.

We're not adding any fertilizer, but we're adding phosphorus and the form of composted manure, not every year.

The plant had to go scavenge for the phosphorus, so it actually rewards the mycorrhizal fungi.

And even though we have less phosphorus in the organic system that we're applying, we don't see phosphorus deficiencies because of mycarhizae fungi, but we've shown with our partners at the USDA ARS and other partners at University of Delaware that, well, at the USDAARS, they're the mycorrhizal fungi experts.

So we're showing that mycohrizal, that increased colonization of mycrorhizo fungi of plants increases ergothionein, and it's a very species-specific. It's not all species of microhizofungi.

There's very specific species, the species and the crop and species have to be paired properly. Oh, interesting. That's something we're learning. And then I think, you know, absolutely fascinating at University of Delaware, Dr.

Harsh Bice in his lab actually used streptomyces coelacolor and found that it boosted growth of the plant. So it's a plant growth promoting rhizobacteria.

It increased ergothionine levels in the plan. and it's actually an endophyte of wheat, meaning that it traveled, living bacteria traveled throughout the wheat and they verified that with fluorescent confocal microscopy.

And so that's another area of inquiry because these plants don't have ergothionein because they want humans to be healthier. they provide a benefit to them.

So actually, some of Dr. Bice's work shows that it looks like it's a, it mitigates oxidative stress. It's acting as an antioxidant in the plant, and we're hoping to investigate how it might mitigate disease.

In humans, we have an active transporter that moves antirgothione to damage tissues, which suggests that evolutionary, is an important compound for us.

How do plants move it? Do they have an active transporter? Well, maybe it's bacteria. Maybe they're actually, you know, when there's a disease, like an insect bites a leaf, the bacteria can migrate to that location and increase compounds in the leaf that are defense against insects or disease.

So, or how about drought or high intensity of sunlight? So these are some of the areas that we're looking at because we know that where we tend to see that organic foods have higher phytonutrient or bioactive compounds.

And we think it's the interaction of the soil microbes that triggers these for the plant, where there's greater environmental challenges to organic food from insects and disease, which triggers that in the in plant.

But it turns out that those are healthier for humans as well. Yeah, that was a huge question. Do we see those by these phytochemical differences in organic versus conventional produce?

And it's such an interesting conversation about the health benefits of that specifically, right? When we talk about health, we can talk micronutrients and that's really important as well, but there's so much more to food.

And this whole conversation about phytochemicals, I think plays a really big part in our health that we're learning so many more about. These are defense mechanisms of the plants.

these are things that help the plant be healthy and then those beneficial properties end up translating to us when we consume plants that have these things.

So the discrepancy between the way things are grown and the density of these compounds I think could play a pretty big role in human health. At least that's what I've learned so far.

Yeah. You probably heard the term food is medicine. We truly believe that. And if that is true, then we ought to be thinking about how we grow our food and how truly we can boost the nutrients in that food.

But that isn't where we've gone in agriculture. food as cheap as possible, which has led to, you know, I don't even have the numbers in front of me, but our healthcare expenses are off the charts, while the average food expenses for the typical household are actually declining in relation to.

I mean, maybe today you're saying, wait a minute, that's not true that, we're seeing inflation. But over the decades, the food dollar or the proportion of people's salaries.

The proportion that we spend on food compared to our earning has declined where the portion that We spend of our salaries that, we spent on health care has increased.

And we think that's because it's an imbalance of not only our diet, what we eat, but the quality of the food that were eating. So that is part of Our journey is how do we improve the Quality of The food.

You're a doctor, Your role is going to be different than my role as a agricultural scientist. Our goal is to improve the quality of the food. Hopefully your goal was to get people to eat the right food or help people go in that direction or to educate the medical community on these intersections.

Yeah, that's exactly the premise of this entire company really is that not all food is created equal, right? And the quality is something that we need to look into.

And so that everything that I'm trying to do is to educate people on how to find higher quality foods. Can we see better health outcomes if we know how find and choose higher-quality foods?

Kind of on that note, when people are looking for higher quality food products, is the USDA Organic label, you know, the best thing to look for? Is there more nuance to that?

How can people find these things? Well, I mean, trust the organic label and it's probably the USTA Organics label is what is I think the most trusted label in the market.

Ergothioneine, Fungal Ecology, and Plant Health

And we're talking about nutritional quality, but we touched a little bit on pesticides, not only on our food, So that's an important health factor, is pesticides in the environment.

So you can feel very confident that by choosing organic, you're having an impact on your health and probably your neighbor's health. And we're trying to add to that the data about the nutritional quality of organic food.

I also tell people, especially when they say, well, we can't afford organic in a marketplace, You know, try to eat local. I joined a community farm where I pick up communities called Community Supported Agriculture.

So I'm going to go today and I am going pick a small share of food that was grown on that farm. And I know exactly how it was produced. Feel confident that they are selecting for flavor, they're selecting taste because I picking it up and probably eating it within a couple of days.

You always tell me to participate in the food system. If you garden, you're getting the benefit of not only selecting what you like the best and nutritional density.

You're getting the benefit of being in nature, exercise, and seeding your body with a microbiome that has important health benefits. Yeah. Absolutely.

I think the next piece or the missing piece, something that I would love to get involved in is the human data side of this. Right? You guys have done a lot of work on the soil health and the translation to the plant.

And done a lot of work looking at, you know, even getting away for, or in addition to the grains that were part of, some of the initial research and getting into different vegetable products and showing the nutritional composition of

that.

And then I think the next piece for me at least is how do we measure this in humans? How do see health outcomes from this? And so I these are all really interesting steps in that direction for sure.

Can you just comment quickly on regenerative systems? or organic alternative systems, and if this is something that is sustainable to feed the population.

Right. That's the question you have, which is, can organic feed world? I think it has to. Otherwise, we're going to destroy the world. But most of the studies that, I should say most studies, the few really good studies.

that have been done, that had been publications like Science and Nature that address this from a large scale. have said, well, organic is about a 25% yield, lower yield gap, you might call it.

So if the whole world, we all switched to organic, I think we would have decades at least before we run out of food. But they also show that changing our diets, reducing meat, consumption.

More whole grains, more fruits and vegetables, especially nuts and seeds, has a much greater impact on being able to feed populations than organic versus not organic.

And then I say that with some of the newer data. I mentioned crop rotation, how organic tends to have improved crop rotations. When they did it, they came back and did an analysis where they looked at improved cropper rotations in some our trials.

We have low yielding organic treatments that we don't recommend to farmers and farmers don t use, but for scientific purposes, we're studying like different cover crops or different green manures and how they, you know, can we get the yields without using other fertilizers.

So if you lump those in, it also makes the yield gap larger. These scientists, a little more precision, said the gap is closer to 9%. All right, so now we're at 9%. It's getting a little bit closer every year as we look at the data.

Just consider this, the amount of, from when Dale started in 1947 to the early 2000s, The U. S. government invested zero dollars in organic research, but conventional agriculture and the government had invested billions of dollars.

In another type of system, since we have an organic program now in the United States, we do have government funding for research in their organic agriculture.

Currently, the amount of funding from the USDA that's allocated towards organic is 0.8% of the total agricultural research dollars, not 8%, 0,8, less than 1%. So when people say, well, we can't feed the world organically, I say we haven't even tried.

I mean, to come up with methods and practices that can improve yields. And it's about feeding people to be healthy. I mean, why do we eat food? We eat to maintain health, right?

And so it is not only about the total number of calories and the yields we can produce. It's also about amounts of nutrition per acre, protein per, you know, vitamins per.

So I think there's so much more to it. Little by little we're getting parity with organic and conventional, but we are really also seeing, especially in developed countries, we actually have higher yields in the organic, and especially if the farmers can't afford to purchase those inputs.

But the industrial complex doesn't like that because how do they make money if those farmers don't buy anything from them? To be honest, when I dig into it a little bit more with people, and it's about, you know, it isn't wholly about organic, like our research isn' completely about not using chemicals.

It's actually about creating closed systems so that farmers are insulated to market influences, right? So right now, the price of all inputs in agriculture are going up because the Strait of Hormuz is closed, fuel prices are growing up.

All agricultural inputs are tied to fuel, petroleum. So farmers that are not organic are going, whoa, you know, this is getting out of hand. But organic farmers have created a system that's a closed system or mostly a close system.

They're completely insulated to these outside factors.

Feeding the World with Organic Systems

And that is the work that we're trying to do. When people say, well, we have to feed the world or the most important thing to increase yield per acre, I think it's so myopic because most farmers can barely even make a living.

They can't even feed their families. And we're forcing this type of agriculture down their throats and never once did we say the goal of a farmer is to take care of their family.

But if you're an accountant, your goal is you go to work, you get a paycheck, and you take of your family, right? No other profession other than farmers do we put the weight of feeding the world upon their shoulders.

So I think it's unfair to even make that comment. I mean, farmers embrace it. They go, hey, it is important. But there's a lot of complexity to what I talked about, but I really disagree with the, you know, if we all went organic, we couldn't feed the world.

Yeah, even anecdotally, there are people that I've talked to that have entered the regenerative space from conventional farming. And I actually talked about significantly higher yields and just the sense of not fighting against nature, essentially, and how they've seen significantly more food come out of that ground.

Here's an example. I was telling the folks yesterday, if you look at the organic wheat in our farming systems trial, because we build up the fertility in the soil over time, we don't use any inputs when we plant our wheat.

In the conventional, you put down 60 pounds of ammonium nitrate because that's what's recommended, and we put down an herbicide. And then there's been a couple of studies.

So in the farming systems trial, in 2014, we planted the whole thing to oats because we said we want to reset the crop rotations. In a study at Beltsville, Maryland, at the USDA ARS system, they had a long, I think it was nine years of organic versus conventional.

They said, okay, this study is over. Just go plant the Whole Field to corn because they don't know what is going to be there. And in both of those studies, you know, in Beltsville, they looked and they said, oh my gosh, what's happening because the corn is so much higher.

And so when they didn't use any fertilizer in, both our farming system trial on oats and the trial in Belfill, there was, more than double the yield in the organic system with no additional inputs.

So what it's telling us is, The conventional system is reliant on continued use of these inputs in order to get that production. The organic system, because we've built up the soil and have soil health and soil fertility, can actually produce high levels of food with almost no inputs.

So I think that is pretty profound. Yeah, yeah, absolutely. I think we do have options here. We have a way forward and I, think that's the story that we need to talk a little bit more about.

So yeah. Thank you. Before we wrap up, is there anything that I didn't ask you that you think is worth mentioning or that? You want people to know? No, I don't think I'm sure there is, but if we touch on a lot.

Yeah. Yeah, this has been incredible. Super, super enlightening. I appreciate all your work and all, your research.

And I mean, you're really helping us understand how to eat healthier, which as we've said, hopefully should have some human health outcomes from it.

So thanks for helping. Well, yeah, I, appreciate it and let, when you, When something comes out, let us know, we can help share it, and if there's other follow-up stuff that you need, like information that might be part of your docuseries, Let me know.

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