Webinar moderator is David Lamm. David is the leader of the National Soil Health and Sustainability team here in Greensboro at our East National Technology Support Center. And with that, David, I'm going to turn the webinar over to you so you can introduce the topic and the presenter.

OK, Holli, I appreciate that. And I want to extend my welcome out to everybody that's decided to join in on this hot and sunny day here in Greensboro. I'm assuming it's about the same across the country. I think we're in for a real treat today with Brendon's presentation. I had the privilege of meeting Brendon Rockey at the National Conference on Cover Crops and Soil Health that was held last February, and was very impressed with what we were able to discuss there, and lead to getting him involved with our cover crop or our soil health series.

This is the seventh out of the eight webinars in our soil health series for 2014, with the next one in August on soil health on organic farms from a farmer's perspective. And Klaus Martin will be presenting that one.

But today let me just do a real brief introduction of Brendon. I asked him how long he's been farming. He says he doesn't know when a starting date was. He's always been on his grandpa's farm which was founded back in 1938 in the San Luis Valley there in Colorado. He raises potatoes, which I think is one of the intriguing things about-- here we think about soil health. We talk about disturbance and stresses on the soil. And nothing, no crop can disturb the soil more than potatoes, except maybe peanuts. But anyway, Brendon's going to talk about how he improves his soil healthy in a system that we would think would be very disturbing to the soil health.

He's a graduate of Colorado State University with a degree in horticulture. And I guess Brendon, I think I'm just going to turn it over to you after that. And one quick reminder, folks. We're going to take questions at the end of the presentation. Be typing them in the Q&A block up there in the corner as we go along, and I'll be consolidating them and asking Brendon questions at the end. But we do want to hold questions until the end of Brendon's presentation today. And Brendon, take it away.

All right. Thanks for the introduction. I was kind of scrolling through the names there on the right, and I recognized a few of those names. So I appreciate you guys that are coming back to listen to me again. I'm glad I didn't bore you too bad the first time you heard me.

I'm going to give you just a little history here on our farm. Like Dave mentioned, it was started in 1938 by my grandpa Floyd Rockey. We do everything at our place a little bit differently, including the varieties we raise. You won't find any russet potatoes on our farm. We do all specialty potatoes. We do a lot of red, yellow, purple potatoes. And we were the first one to bring fingerling potatoes into the country as well. We do some Fresh Market packaging of the fingerlings. We have our own packaging shed. And we also do a lot of certified potato seed as well.

We are on a two year rotation, so we've got 500 acres of farm ground total. And out of every year, about half of that is going to be potato production. And then the rest will be green manure, which we'll get into quite a bit.

We are technically farming in a desert, so everything is irrigated. We get less than six inches of annual precip a year, so that's not near enough to grow a potato crop. And we are farming at 7,600 foot elevation, which is pretty interesting as well.

Now I did mention my grandpa started the farm. And a lot of what I'm going to talk about today, a lot of people want to give me credit for what we've done here with our soil health. But what it really is is it goes back to a philosophy that I was raised with, going back to what my grandpa always told us growing up. And he truly believed that you have to take care of the soil before the soil can take care of you, and I think that's something that we've kind of gotten away from in agricultural. We've forgotten all about the soil and we just care about the plant and the crop now. So that's one thing we've started coming back around to.

Now like Dave mentioned, we are potato farmers, so that's going to be the focus of what I'm talking about here today. But keep in mind, a lot of the fundamentals and principles that I'm talking about here are universal, and they can be applied to any crop grown in agriculture. And a lot of what I've learned has been from guys growing other crops in completely different situations, but the fundamentals are all going to be very similar.

So here's a picture of a purple viking potato that we raised here, and it's going to be the focus of what I'm talking about. Now no matter how you're raising this potato crop, there's always going to be certain issues that we're faced with when raising this crop. We're going to have insect pressure, weed pressure, parasitic nematodes, fertility issues, soil borne and foliar diseases, and then water as well.

And no matter what your approach is, all of these inputs or all these factors can have a direct impact on the potato crop itself. So it's something that we're going to have to address.

But here's where things get a little bit different on our farm is how we approach these problems. In conventional agriculture, I think most of the time that we're trying to deal with these problems it tends to be a very linear approach. And what I mean by that is when we have something that's directly impacting the potato crop, we try to deal with that problem first hand. So in a lot of cases you'll see a very common theme here is cides are often used. And what that means is you're going in and trying to kill the problem off. And what we've tried to do on our places, we're trying to get away from killing off our problems and actually bringing in life to start controlling our problems for us.

So a lot of people hear me talking about not using these different cides and not trying to kill things off, so they assume that we are organic. So one thing I want to clear up right away is we are not certified organic. It's something that just really doesn't fit our production model. But we definitely aren't on the conventional side, as far as the fertility and the chemical use goes.

So I've actually had to come up with a new term to kind of define what it is, how we are farming. And this is the best I can come up with. I really liked the term biotic farming, and here's how I defined it. I consider it to be an agro-ecological approach that nurtures the relationships between all living and nonliving components of the complete system. I really feel like this encompasses what we are trying to do on our farm.

So when you start talking about biotic farming, it really disrupts the linear approach that we have been taking in conventional agriculture, because there's these other components that we have to take into consideration such as predatory insects, carbon, the beneficial life in the soil, soil structure, and the beneficial life on the crop itself. So as we start taking that linear approach, the conventional agriculture tries to take-- you can see how when you start looking at the big picture and really taking a step back, that linear approach becomes much more difficult.

So one good example would be insect pressure. In potato crops, aphids are a big issue, especially in certified seed, because they can transmit the virus from one plant, a diseased plant to a healthy plant, and infect it. So we all are concerned about insects.

But in conventional agriculture, usually the approach is you have a pest out there causing problems, so

let's go in with an insecticide and try to kill the problem. But what we need to do is, like I said, take a step back. And when you start looking at the big picture, you start to realize that you can actually create other problems when you take this approach.

For example, you might be killing off a predatory insect population in your field which was actually helping control that pest population to begin with. And a lot of people think, well, there's different insecticides out there that only attack the pest insects. They won't kill off the predatory insects. But one of the problems with that is when you remove the food source, you're going to starve off the predatory insect population as well, so you don't have that defense mechanism in place to help control those outbreaks of pests.

But the other thing is I think it's pretty easy to see how you could disrupt this system here by killing off the predators. But we have to keep in mind that these insecticides are also very damaging to a lot of the other insects that are down in the soil as well, which all play a certain role in the complete system and are very beneficial if everything is in balance.

So I think one of the biggest problems that we face in potato production especially is the overuse of fungicides and soil fumigants. And once again, we have a disease that might be thriving on a potato plant or down in the roots system, causing us problems. So our initial response is, well, let's go out and kill the problem, because then we won't have to deal with it anymore.

Now I'm not going to argue that these fungicides don't do a really good job of killing off these specific diseases at first. But that's where we start running into trouble is you start developing resistance to these different chemicals, and they lose effectiveness as time goes on. But like I said, once we look at the biotic system and how everything functions together, we need to keep in mind that these fungicides can also be very damaging to a lot of the beneficial fungi that thrive in the soil and on the plants themselves.

And a lot of these fungi that are thriving in the plant and in the soil are actually really good at controlling those diseases for us to begin with. But once we go in and start attacking the one fungi that's causing us trouble, we're killing off all the good stuff as well. We're throwing everything completely out of balance. Now you're actually more susceptible and more prone to being overrun with these fungal pathogens. So a lot of times we're creating our own problems and we are our own worst enemy.

And another really good example of that is parasitic nematodes. One thing I really noticed in potato production in the valley-- and I think other areas would agree with this-- but where we're seeing the worst outbreaks of parasitic nematodes in the soil now are in areas where soil fumigants and fungicides have been overused. I think a lot of time people have trouble making the connection between a fungicide, which is killing off a fungi, and what impact that might have on parasitic nematodes, because that's a little worm-like creature in the soil, and they're not related at all. And the fungicide isn't killing off the nematodes itself.

But what's going on is there's actually tons of beneficial fungi that thrive in the soil. They can actually trap and kill these nematodes for us. And before we were using these harsh fungicides, we had these natural populations out there that we're doing a really good job of controlling those nematodes for us.

So here we come in trying to control a fungal pathogen with these fungicides. We're killing off all these beneficial fungi as well. Now we've created this opportunity for the nematodes to come into our system and overrun us, and now they're actually getting to the point where they're causing economic damage in the system.

So I just really want to emphasize, I think one thing I'm seeing over and over again is it seems like we are the ones that are creating the problems that we're dealing with now. So we're the ones that are going to have to start solving these problems.

So now we have a parasitic nematode problem in our soil, which we happened to create ourselves, but a lot of people don't want to recognize that. But now our approach is we have this parasitic nematode causing trouble, so obviously our approach is going to be to come in and try to kill that nematode off. So now we're going to start using a nematicide. So here is another cide that has come into our production model, trying to kill off our problem.

But one thing we need to keep in mind here is that there are a lot of nematodes that thrive in the soil that are actually very beneficial to the plant and the soil, and actually can help control other pest populations as well. And when we use the nematicides, we might be wiping out these beneficial populations as well. So out of all the different species of nematodes that thrive in our soil, less than 10% of them are actually parasitic, yet they get all the attention and they're the ones we're going out there and trying to kill.

Fertility is an interesting one as well. So this is one that it doesn't mean using a cide, doesn't involve killing off anything, but it has its own detrimental effect as well. And when we start using the NPK fertilizers, the inorganic fertilizers. Now these fertilizers do a really good job of providing nutrient directly to the plant, but the trouble we start running into is it's a very inefficient system. These inorganic fertilizers are water soluble, so they leach very easily. They're also prone to volatilization. So it's a very inefficient system.

But when you start looking at the biotic impact, the thing that comes along with these inorganic fertilizers are high amounts of salts. And when we over apply these salts to the soil, it actually creates an environment that is not beneficial to the life in the soil. So we can actually start killing off a lot of this beneficial life through the overuse of these inorganic fertilizers.

So you'll see the beneficial soil biology in the middle of that slide getting a lot of attention there. And it's really kind of the central hub around everything. But what we really need to look at is not only the life in the soil, but its relationship to carbon and soil structure. You really need that beneficial life in the soil to help break down carbonous material that gets added to the soil, such as plant residue.

But also the carbon is very important to feeding that life in the soil. It is the energy that drives all life in the soil. So when our farming practices are focused on inorganic inputs, we are not having those carbon inputs to help drive that life in the soil. And also the beneficial life in the soil is very important for creating aggregates in the soil, which leads to better soil structure. And the carbon itself can actually improve that soil structure even further.

And the reason the carbon and soil structure is so important is they can have a huge impact on our water, especially in our situation with the irrigation. When you have poor soil structure, you have very small, tight pore spaces, so it's actually hard to get water into the soil to begin with. And then when you don't have the carbon in the soil, it does a very poor job of holding onto that water once it gets into the soil.

So here's a problem we used to have back when we had unhealthy soil. We had very little life in the soil, we had poor aggregation, very low soil structure. We actually used to bury our center pivot every single year. And it's something we used to just accept as a fact. We used to blame the soil parent material as the problem. It happened to be one of our sandier soils. And we just accepted the fact that we were going to bury that pivot. And we would go out with our straw bales, which was just another Band-Aid.

And we'd get that pivot unstuck and get it around for the season. But one thing we've started to notice is what impact we've had on our soils in this problem here by bringing the life back in the soil.

So when it came time to go get it, take a picture of a pivot being buried, I couldn't even go out to our fields anymore to take this picture. So I had to go across the road to the neighbor's farm to show this situation. And the reason it's important to realize that this field is actually straight across from ours is we thought it was the parent material. But this field has the same parent material as ours, and we're not sinking our pivots where they still are. But when I look at the situation here, I see a lack of soil structure and a lack of life in the soil.

So now we have poor soil structure and we have low carbon in the soils. We actually end up waterlogging our soil. When you have those small pore spaces, when you irrigate, you lose the oxygen that's in the soil. So that actually create an ideal environment for a lot of the pathogens that thrive in the soil. Most of the pathogens that attack potatoes are going to thrive in anaerobic situations, so very little oxygen is what's actually creating the habitat where this stuff will thrive.

And the same goes for a lot of the foliar diseases. A lot of times they occur when you're over watering a crop, the plant is wet real often. You remove the oxygen from the system, and that's when a lot of these blights come in and overtake you. And then also it turns out that weeds really thrive in waterlogged soils as well. Weeds tend to really like really stressed soil, and over watering can be one of the situations that lead to that situation.

And then since we're on the subject of weeds, there's a lot of other factors here that we've disturbed that also create ideal environments for weeds to thrive. There's some really good charts out there that actually can go through and show you what soil situation certain weeds like. And most of the time most of the weeds we're dealing with in potatoes really like poor soil structure. They like tight soil. They thrive in soils with low organic matter, which means they're lacking in carbon. And a lot of times they will show up in situations where there's a fertility imbalance, which comes in when you're trying to over apply inorganic fertilizers.

So now we have a weed problem, which we actually created ourselves. But now again, we're going to come in with the same approach that we've been taking with everything else. We're going to come in with a herbicide and try to kill the weed off. Now there's some herbicides out there that do a great job on killing certain weeds, but we also have to be careful because this is one of the cides that can have a

direct impact on the potato plant itself. If your timing is wrong, if you pick the wrong chemicals, you can actually do a lot of damage to the potato crop itself.

Now at least when it comes to weed pressure, we do have some options there. And mechanically controlling weeds is a very viable option in potato production. So we can actually till the soil to control our weeds, but we have to be very careful with this one as well because tillage itself can be very damaging to soil health. It actually does a really good job of removing carbon from the soil. It can actually physically break down the soil structure by that iron going through the soil and breaking apart those aggregates. And it can be very damaging to the beneficial soil biology, particularly the fungi that thrive in the soils. They have these long hyphae that are very brittle, and it doesn't take much disturbance to really throw off those populations.

So this is where I feel like we were, and this is about 20 years ago that we really made this transition away from this type of farming. Because I felt like we were having all these problems. And when you started thinking about it, every time we came in and thought we were solving one problem, it seemed like we ended up having more and more problems rear their ugly heads, and it was actually a result of our own doing.

But what's really nice about this system here is we do have options, and we have the ability to wipe the slate clean and start fresh. But it's really important to recognize how we got into that situation and how we were creating this damage to begin with.

So this is basically what we did in our operation is we sat down and just recognized where the damage was coming from. But we wanted to just start cold turkey. We got rid of all the negative impacts that we were having, and we wanted to start building the soil. And the only way you can really do this is with what we call soil primers. And this is a term I stole from Gabe and Paul Brown up in North Dakota, and I think it's a really fitting term. But what that means is it's anything that's actually going to be priming your soil for success.

So here's a list of the soil primers that we're using on our farm that I'm going to be talking about a little bit more. So we really use green manure crops for our rotation crop, using some companion cropping, which I'll get into in greater detail. But all of our fertility inputs are carbon-based, and then we're also adding diverse populations of known beneficial bacteria and fungi to help support this system for us.

So when you start using these soil primers, really the first thing you're really doing is supporting that beneficial life in the soil, because that is really where everything starts at. So a lot of these primers, I was talking about those inoculates we were using, we're actually introducing biology that's been missing from our system because we've killed a lot of it off. We're bringing that life back into the system. The green manure crops just bringing in different plants with different root zones are all helping build that life in the soil.

The other thing that's really critical here too is I mentioned the carbon-based fertility and the green manures. It's all about adding carbon into the soil, because that is going to be the energy that drives all of this life in the soil.

So now we have that life in the soil and we have the carbon to support it, now we actually start building a strong relationship between these three components. It's kind of like a three legged stool. You start damaging one, it has an impact on the other two. Now when you start improving one of these, it improves the other ones as well.

For example, you have the life in the soil now, which is really good at taking little soil particles and gluing them together and creating these aggregates, which creates good soil structure. And as your soil structure improves, now you have a greater environment for that life in the soil to thrive. So the two really feed off of each other.

And now you have the carbon to help support that as well. And the carbon itself actually improves your soil structure even further too. So this is one thing we've really noticed on our farm is just the tilth of the soil, how much it's improved. It's very loose, light soil, and it's improved a lot of other factors as well.

One of the biggest impact that these had for us is our irrigations. Like I mentioned, we are farming in a desert. We've been suffering from a drought. So water is very critical to us. So anything we can do to help save water is very important.

And now that we have this really strong soil structure, we have high carbon in our soil. I'm actually able to irrigate fewer times per season, and I'm able to put less water on pre-irrigation. The reason I can get away with fewer irrigations is because I've got that high carbon in the soil, so once the water is in the soil, we're holding onto that water much better. And the reason I can get away with less water pre-irrigation is because we have that strong soil structure. We have really good pore space. So when I

irrigate, the water's going to right down to the root zone, right where it belongs. We don't have water running off the hills and out the edge of the field.

So here's my water use since 2006. And I'll explain this chart to you a little bit here. So this is two full circles that we farm. So we've got circle number two and circle number three. Now the peaks at the top there is when it's a potato crop, and at the peaks at the bottom is when we were growing our green manure crop. So it kind of gives you a pretty good idea of how much water we're using every single year to grow a potato crop. And we've used as little as nine inches and up to 17 inches, because this is strictly irrigation water. So we do get a little bit of rain during the growing season, and this will impact it somewhat.

But as you can see, I would say 12 to 14 inches of irrigation each year is about what I need to grow a successful potato crop. Now you talk to guys in the valley that have a poor soil structure, very low carbon, a lack of life in the soil, they claim that you can't grow a crop with less than 18 to 20 inches. So here you can see a huge improvement in our water.

And then we used to grow a barley crop as our rotation, and we got away from that for water saving. So here you can see I'm using about five to six inches to grow a green manure crop in rotation. So I'm averaging about nine inches of irrigation on my farm across the entire farm every single year, which is a significant savings over what we used to be doing with the different rotation and with poor soil health.

So now if you remember that picture I showed of that center pivot getting buried all the way down, this field here shows what our sprinkler tracks look like now. By improving that soil structure, no longer are we making huge ruts out in our field. And we're actually to the point now where at the end of the season, the sprinkler's still climbing over every single potato row. And I think that's really important to keep in mind, just showing the value of that soil structure. And if that soil has enough strength to support the weight of that sprinkler, that means that those soil particles are getting compressed together, being pushing all of the oxygen out of the soil when you're irrigating. We're able to maintain that soil structure throughout the entire season.

So now that we're able to properly water our crops, now we don't have plants that are wet as often, so this has been great for controlling early blight on the potatoes. We've seen a huge decrease in soil borne pathogens, because a lot of those pathogens really do well in over watered, waterlogged soils. And it's had an impact on our weeds as well.

We still have weed pressure on our farm, but the species of weeds that are driving in our soils now are much different. We don't see the sunflowers and thistles anymore, which are two weeks that tend to thrive in waterlogged soils. Now we see more lamb's quarter and pig weed, which are both indicators of very fertile, well drained soils.

So some of the primers we're using, some of those inoculates we're using, also further our control of early blight just because, for example, bacillus subtilis is one of those species and one of those that does a really good job out competing the disease on the plant itself. So we're constantly adding this diverse life to the plant itself. And we've seen a huge decrease in our soil borne pathogens as well, a lot through just having the proper environment out there, but also these competitive species out there that are doing a great job of helping us control diseases in our potatoes, such as rhizoctonia.

We've seen a huge impact in our fertility. I mentioned earlier how inefficient inorganic fertilizers are, just because we're constantly volatilizing and leaching the leftover fertility. But what's really nice is when you're dealing with the carbon-based fertility, is if you put more out there than you need that growing season, since it's attached to that carbon, that fertility really doesn't go anywhere.

And we're actually seeing long-term accumulative effects by taking this approach, to where we're actually getting to the point now where we're greatly reducing our inputs every single year because we've had enough of this carbon-based inputs that we're building this reservoir, this bank of nutrient in the soil, and now we're getting the long-term benefits of that as we move along. And it has a huge impact on the economics as well when you're able to reduce your inputs while maintaining your yields and improving your quality all at the same time.

Back before we made this transition, just like everybody else in the valley, we we're starting to see an increase in parasitic nematodes. But through the use of green manure crops and just by bringing that life back to the soil, creating an environment where that fungi is now thriving in our soil and trapping and killing those nematodes, now we no longer have a nematode problem. And not once did we ever go out there and actually target the parasitic nematode, and we never tried killing it off within a nematicide. So we were able to start solving our problems by bringing this life back into the system.

And then there's been some other impacts on our weed populations as well. Like I said, a lot of these weeds tend to thrive in stressed soils. But as we bring the carbon back into the soil, we bring our fertility

back into balance, it's helped us tremendously, helping control the weed populations in our potato crop as well.

Now insect populations. This has kind of been one of my latest obsessions is really focusing on bringing predatory insects, really creating an environment to where the predatory insects will thrive in our system to really help control the insects for us as well. And then you'll notice I've got beneficial foliar biology coming over to help control the insects. And that's one thing that's really interesting when you start looking at biological control of aphid. You start talking about biological control, and most people recognize ladybugs. They do a great job of consuming aphid. They think, well, that's all I need out there is ladybugs.

But the diversity in the insects out there is just as critical. You just go online and just do a quick little search on Google for biological control of aphid, and this is the list I came up with in about five minutes of all the different insects out there that actually do a really good job of controlling aphid. And then if you'll notice those very last two, they're actually two fungi that can grow on a potato plant and help control aphid as well. But if you're out there constantly spraying the plant with fungicides, you're killing off these beneficial fungi as well.

Now, one thing I was able to realize, what you see in this picture here is actually my greenhouse crop. Since we grow certified seed, we grow plantless in a tissue culture lab, and we grow a crop out in a greenhouse crop. And I understood the value of predatory insects for controlling aphids. So what I would do each year is I would actually purchase beneficial insects. I would buy lace wing and ladybugs, and I would release them in my greenhouse. They'd be there for about a day or two, and then they would leave.

So what I started to realize is the reason that they weren't sticking around is because I didn't have the environment for them to stay there and thrive. So what I've actually learned is there are some flowering crops out there that produce high amounts of nectar, which can actually sustain these predatory insects. You can actually build these predatory insect populations before the pest insect actually arrives.

So now what I do is I've got a multi species flowering crop that I plant directly in with my potato crop. So here on the bottom is a list of all the different flowering crops that I grow in my greenhouse with my potato crop now. And once I get the flowering crop established, now I can actually go in there and release predatory insects, and instead of them leaving, they're actually sticking around and

reproducing. So now I'm only releasing adult ladybugs in my greenhouse, but yet you can go in there and find eggs, pupae, and larvae in my greenhouse crop throughout the entire season now. And now I no longer have to worry about aphid infestation, because I've got this defense set up in my greenhouse crop.

So now here's a really good indicator of how we are farming now. And I think it's really important you know, you really see soil primers as being the foundation for this system, and that beneficial life in the soil is another really important component.

But one thing that that diagram doesn't really do a good job of explaining is how important diversity is on our farm. So I'm going to go into this just a little bit, but I'm sure this is one thing, it'll be kind of repeat for a lot of you, because a lot of guys that are doing the green manure crops are really understanding the value of diversity. So I'll breeze through this one pretty fast.

But I did really like this quote by Daphne Miller. She's the author of *Farmacology.* And a lot of times when you start talking about diversity in green manure, crops, you'll hear a lot people say one plus one doesn't always equal two. And I think that's a good way of looking at, and I think this quote here actually makes even more sense out of it.

You know, I was talking about that linear system, that conventional agriculture tends to apply. And when you put in x and get out y, you expect 2x to give you 2y. But when you start bringing in diversity, this isn't necessarily true. We find ourselves putting into 2x now and getting a much better return on this by bringing that diversity, because there's a lot of synergy there, a lot of these things are complementing each other and making them all function more efficiently.

So here's an example of one of the multi species green manure crops I have used in the past. And that I'm not going to go into too much detail on this one. I might use the green cover seed cover crop calculator for putting these mixes together. And just like everybody else, I always try to cover the four main categories here, as far as the broad-leaf grasses, warm and cool season. So here's how one of my dream manure mixes would break down into those four categories. And then we always have an emphasis on the legume crops.

And one way I like looking at it is each of these green manure crops have a lot of specific benefit to them. And we used to think in conventional agriculture, well, I want the benefits of each of these, but

you've got four different categories there. That means it's going to take four different years to grow those crops out to get that benefit from it.

But what we're starting to realize is by bringing these species all together at the same time, we're going to get the benefit of each of these individual species every single year. And that's where these multi species green manure crops have really leapt us forward as far as our progress, because we're seeing things happen so much more quickly than if we were to come in with individual species of these green manures.

And here is one thing where I will vary from a lot of the no till guys out there doing the cover cropping is I do incorporate my green manure crop. So on the picture on the left there, we're actually going through and chopping the green manure to help break down the residue. Then we will make one single path with a sunflower mulcher to help get that green manure incorporated into the soil.

And the whole reason behind that is with the rotation crop being potatoes that next year, if I have too much residue out there, the way the equipment is designed for potatoes, that residue can actually become trash to us and can become a great hindrance to us. So we have to be very careful when it comes to managing our residue. So here's what it looks like after the one pass, and then on the left there, I'll just get one last time just to incorporate that green manure before I make rows in the fall for my potato crop the next season.

But one of the main reasons I wanted to talk about diversity a little bit is we've seen such tremendous benefits from diversity in our rotation crop. Now we used to grow a potato barley rotation, so half our acreage each year would be potatoes, the other half was barley. And then when we brought in the green manure crops, the first year we did a monoculture of Sudan. We were really targeting nematodes with this. And we saw great benefit from that Sudan. But then I happened to meet Jay [INAUDIBLE], in North Dakota, and he really helped me realize the importance of bringing in diversity.

So this is the very first diverse mix that we planted on our farm, and it was a seven species mix. And at the time I thought seven species was crazy. He had a hard time talking to me into that many species out there at one time. And after that one season, we were just absolutely hooked. We saw the benefits of that seven species, so we wanted to bring in even more diversity. So each year I found myself adding more and more diversity because we saw the benefits of bringing in more diversity. So each year we kept growing more and more, started bringing in some stuff that we could graze. And this is actually my

green manure mix this year. So we're up to a 15 species mix.

But the trouble with this is we're seeing great benefit from the diverse mix on a rotation crop, but we still had a monoculture of potatoes on the other half of the farm. And that was disturbing to me.

So actually I came across this idea on accident. I hope you can see that in the picture there, but what we've got is a potato crop here, and there were some peas growing up in that one row. A long time ago, we actually use to raise field peas, and we would get some volunteers coming up once in awhile.

One day out in the field I noticed some peas growing. And if normally I'd see a weed out there, I would pull it, but with those peas I just let them be, because I figured they weren't doing any harm. And that's when the light bulb kind of came up. If those peas aren't doing any harm out there, maybe I've actually got something to gain from this. It is a legume, so it's adding nitrogen to the soil. It's also a diverse root system. Each root system's going to foster different life in the soil. And it's also got some flowers on there, so maybe that'll attract some predatory insects.

So what we did that next season is we hopped on top of our potato planter and just planted some peas by hand just to see how it did. And we liked the idea so much that we actually ended up the next year incorporating peas into our entire potato crop as a companion. We actually designed a potato plant to the help this for us. We didn't have time to sit back there the entire time planting peas by hand. So we actually designed this potato planter here that had some Gandy boxes on the front of it. And these Gandy boxes are driven, along with the cups on the planter that are planting the potatoes, and it actually plants the peas for us. The peas fall down in those tubes and get planted right along with the potato seed peas.

We like the peas so much that now any time you start dealing with diversity in these mixtures, you kind of create an addiction. You introduce one species and it's never enough. You always want more and more and more. So the next year we actually incorporated chickling vetch as a companion. It was another legume, but it was a little differently than the pea. There's chemically different things going on in the soil, blooming at a different time. So we wanted to bring in more diversity there as well. They both had a big seed piece, which was really important, because we are planting this crop very deep. Now you'll see on the left there is a potato seed pea that's sprouting, and on the right is some peas and chickling vetch that are starting to sprout and come up.

The first year I did this, I was worried about the pea coming up at all. But what we ended up having with the exact opposite problem, and we're actually to the point where the peas are beating the potatoes out of the ground. And we actually kill a few of them off when we're controlling our weeds. So I was very pleased that that was able to work for us. So here's some pictures of peas and chickling vetch coming right alongside in my potato crop here.

And one thing that's interesting when I first came up with this idea and talking to a few guys is they were actually opposed to it because they said, well, if you're going to introduce more plant species out in your potato crop, you're going to create competition. But what you see here is there's a line right down the middle, and on the left was that first year, that was our control strip, and on the right was where we had the peas planted. And when you're doing a companion crop, it's actually possible to come up with a very balanced mixture to where not only did we not create competition, but what I feel like we're doing is we're creating a collaboration. And everywhere that we had our peas versus the control strip there, wherever we had the peas, we actually out yielded the control strip. So not only were we not introducing competition, we are actually helping that potato crop thrive and produce even better.

So now so we have the peas and chickling vetch out there as companion crops, and now I've started bringing in the buckwheat for a lot of the same reasons that we have the flowers out there in my green manure crop or in the greenhouse crop, excuse me. The buckwheat does a really good job of attracting predatory insects. So now we have another role the companion crop is filling for us. So here you see the chickling vetch on the left and the buckwheat on the right, both doing really well out in the potato crop.

And here are some of the legumes that are coming off the peas. So I mean, just gigantic legumes. So we know we're getting some tremendous nitrogen fixation from this idea. And then this year, like I said, I'm never really quite content with where we are on diversity. So now I started bringing and desi chickpea as well, and I'm very pleased with how it's doing.

So now you look at this system here. Now when we start bringing in the companion crop, what I really like about this is any time you introduce more life into the system, it strengthens this approach even further. So now it's had an impact on my fertility, because I've got legumes out there every single year now adding nitrogen to my soil. You've got a diverse root system, which feeding more life in the soil to releasing root exudates, improving the carbon content in my soil. And now we've got the flowering crops

out there to provide the environment for the predatory insects.

So now you can see where we're actually getting somewhere with the diversity now. So one thing I noticed last year was having the buckwheat out in my field. It really did a great job of bringing diverse, predatory populations into my field. So up on the left hand corner here you see a green lace wing, is a really good consumer of aphid. You've got a checkered beetle just to the right of it. To the bottom there is the lady beetle, which we all know. And then a Collops beetle down there at the right. So now I'm not just relying on the lady beetle as a predatory insect. I've got a diverse population of insects out there helping control my aphid population.

But one thing that's important, we understand the value of having those diverse insect populations out there, but yet I only had that buckwheat out there for really attracting them. So I really wanted to take it a step further. And what we did this year-- so now you see the strip in the middle there-- I've actually introduced my flowering mix into the potato crop as well. I've got strips through the potato field that are committed for the flowering mix, and I also planted it around the perimeter as well. And so far I'm very pleased with the diversity I'm seeing out there in my insect populations. You can't have diverse insect populations without having that diverse flower plant population to support it.

So now you can really see how many different species I'm planting on my farm, all for the sake of growing a potato crop. This is how important we think diversity is to the complete system. I think a lot of people think we've taken it to an extreme, but I'm not content yet. I'm still looking for more and more ways to bring in even more diversity here.

And one thing that's important to is just each of these that are listed on each of these categories, it's not like each of those only serve a certain role. You'll see a lot of these are actually planted In multiple areas. So like peas, for instance, I've got planted as a companion crop in my potatoes. I've got it planted in my flowering mix because it does a great job of attracting predatory insects to my potato field. And then it's also in my green manure mix as well for the nitrogen fixation. So it serves multiple roles on my farm.

So one thing I think is really important is to take a step back and look at the two systems that I've talked about today. And remember I used the term by biotic farming. I think another reason I really like using this term is I think it plays very well when you look at the two of these side by side. Because now that we know what biotic farming is, we have a decision that can be made. We can either be probiotic our

antibiotic. And I think this does a good job of explaining why these systems are good and why they might be failing us.

And it's interesting when you look up antibiotic in the dictionary. This is the actual definition that comes out of the dictionary to define antibiotic. It means to prevent, inhibit, or destroy life. And that is what's wrong with conventional agriculture today. Everything that we are applying to the crops, it's all about destroying and removing life from the system. We need to get back to that probiotics approach where we're actually promoting, enhancing, and nurturing life in the system.

So a lot of people ask me, how do you know that your system is working? And there's lots of indicators. Like I said, the quality of our potatoes. One thing that I've noticed lately though is that the health of our seed pieces even are very dramatically improved. So this is a picture of some red potatoes at harvest time. And we've got the new potatoes on the right there. And we've actually gotten to the point now where we actually have to sort out the seed pieces at harvest time now too.

Whereas before in our original system, most of these seed pieces would be completely decayed by harvest time, and it was never an issue. So this gives you a good idea of just how healthy our soil and plant are that it's not even consuming that seed piece, and there's actually a lot of vigor left in the seed piece even at harvest time.

And here's another really good example too is just a real simple test you can do is just pulling up the roots that are in your soil, and seeing how that soil is sticking to an aggregating around that root zone. And here's a good example. So you now that it's a good indicator that that plant is releasing the exudates and feeding that life in the soil, and there's the very first step of those soil aggregates being formed out in our soil. So we see a lot of indicators out there to show that we are on the right track here.

So as we look at this picture, I keep emphasizing the point about bringing more and more diverse life back into the system. And I think we can take it even a step further. One thing I'm going to introduce to my farm this year is cattle. We actually designed our green manure crop to be grazing friendly, and we're actually going to bring some cattle out on the farm to help graze that green manure just to help cycle nutrients. And there's a lot of things going on in a cow's stomach that can't be replicated in any other way.

So just by bringing in this diverse life, I think we're going to be able to strengthen this system even further. So once we get everything figured out with the cattle, I'll be very open to bringing in diversity in our livestock as well too. I think there's a lot to be gained from different animals out their grazing all at the same time.

But I think as good as this is as far as growing the potatoes and everything, we've talked about life a lot today, there's still one thing I have yet to mention. And it's the most important thing is we really need to keep the end consumer in mind here too. I'm very proud of the crop we are growing. We're growing it without toxic chemicals. We're providing a healthy soil to grow the healthy plant, the healthy plant's growing the healthy tuber, and that's going to provide healthier people when we are consuming these tubers. So I think it's something we need to keep in mind when we're looking at all the life that's involved here, because we can't forget about ourselves.

And that's why these two guys here are a lot of my motivation. This is the next generation of Rockey Farms here if they choose. And I'm not going to hand over on a farm that's been depleted and degraded. I'm going to make sure that if they want to come back to the farm that they're starting off with a healthy soil that's functioning properly, because that's going to give them the best chance for success. And it's providing them with a crop that they can consume and help improve their own health as well.

So that's basically all I've got for you guys today. I just want to mention a couple of things. We do have a Rockey Farms Facebook page. It's a good way to communicate with us. I try to put updates on there, any of these wild and crazy things that we're trying for the year. So I encourage you to check us out on there if you want to communicate with me later after this webinar. And then I also do have a side business I work with called Soil Guys, that we've been working with a lot of these other inputs. A lot of the philosophy from this presentation will be on there. And then my contact information will also be on there, so it's a great way to get a hold of me. So that's all I've got for you.

Wow, Rockey, I don't even know what to say, Brendon. You've done such a wonderful job, and we've got a ton of questions coming here. So I just want remind folks, if you're interested in asking a question of Brendon here, type it in here and I'll try and get through as many as possible. Kind of going back-- most of the questions came in at the end there when you talked about diversity, but there was a few that came in. This idea of weeds and fertility changing with soil infiltration, density, those types of things, could you talk a little bit more about that, and what maybe led you to see that or make that observation?

Yeah. There's some really good books out there on the subject. Like *Weeds, Defenders of the Soil.* I think what we need to do is recognize why weeds are growing. And every single time you see a weed thriving in the soil, it's because it's trying to correct something that's wrong out there. One of the main problems that it's trying to correct is bare soil. That's something I'm not going to be able to get away with with the potatoes, because I can't rely on the high residue amount out there. But also the fertility imbalances, they talk a lot about that as well. A lot of the micronutrients, when those get way out of whack, a lot of times these weeds are growing to help correct that problem for us.

So we always look at weeds as being the bad guys, but most the time that weeds are thriving it's because they're actually trying to correct something that's wrong in the soil for us. So I would encourage you go out and find some of these publications, and it gives you a lot more detail than I could ever touch on.

As far as an observation, like I said, looking at the weed species that thrive in our soils now, like sunflower I think is a great example, we used to have a ton of sunflower out in our potato fields. But now you can't find a single sunflower out in our field. And when you go into these charts and look at what a sunflower is an indicator of, most the time sunflowers do really well in soil that are waterlogged, have poor soil structure, really tight soils. Because that sunflower's trying to-- it likes that excess moisture and actually does a good job of using up that excess moisture to bring that soil back into balance. So once again, we just need to observe what the weed is trying to do for us.

What was the name of that publication again, Brendon?

One of them is called *Weeds, Defenders of the Soil.* And then there's a bunch more out there as well. You can just go on Amazon and there's several really good publications on the subject. And a lot of them really go into the fertility aspect of it as well.

Do you have something similar? I notice your discussion about the parasitic nematodes and that relationship too. Is there a reference that you have where you found a lot of information that was beneficial along those lines too?

A lot of that's been from just different people I've met, a lot of guys producing different products out there, a lot of guys with inoculums with these known fungi for controlling the nematodes. There are some really good books out there. I know Jerry Brunetti's latest book touches on nematodes quite a bit.

I can't think of the name of it.

Another book that I really like is called *Farming in Nature's Image.* If I were to write a book myself, there's two chapters in that book that would be eerily similar to what I would write if I were to write a book, so that's one of my favorites. So that's *Farming in Nature's Image.* I'd really encourage you go go get that one.

OK. I had a question about your use of chemicals, which ones you might use. And then also maybe what's your fertility program look like, as far as supplemental materials that you're using?

Yeah, we are completely chemical free. I don't use any chemical on my farm anymore. Well, I'll back that up. The one chemical we do use is we still use sulfuric acid as a line desiccant. With our growing seed and especially potatoes, once we get our potatoes to a certain size, we need to terminate the crops so they quit growing. So we use sulfuric acid, but we don't feel like that has any other detriment on the soil health. But as far as the cides, we don't use any herbicide, no fungicide, no insecticide, no nematicide. We don't use any of those chemicals anymore.

As far as the fertility goes, compost is still the foundation of our fertility. When we were doing a potato grain rotation, we were doing three times the compost every single year. As we got away from the grain and doing the green manure crop, we were able to cut that in half. We just did three ton every other year. Because we weren't removing anything, because we were harvesting that green manure crop.

But as we've brought in diversity, brought in more legumes, the soil health has improved as a whole. We got to the point where we are able to back off to a ton and a half of compost every other year. And we were actually to the point this year, we had one field that had so much built up nutrient in the soil that we skipped the compost application altogether this year. Because we actually got to the point where we were worried about having too much out there. And then I also use a fish-based fertilizer, and then a lot of those other inoculates. Through the pivot, we [INAUDIBLE] those on.

Are you using your base for your compost? Is there anything particular about that?

No, we're real limited on what we have as a parent material there. We used to have turkey manure in it, but a lot of the feedlots that had the turkeys in them got shut down, so we had to move the cattle. The manure that's used in it comes from feedlots, which isn't ideal, but we just are really limited on our resources there. And then it's usually mixed in with barley stubble, which is great because it's readily

available here in the valley. So that's a pretty cheap carbon source that we can add in for that.

And then I can actually, a lot of times I'll take some of the fish product and mix it in with the compost before it gets spread. And what we'll do is when I'm incorporating my green manure crop, so this year when I incorporate my green manure crop, that's when I'm going to spread my compost after that crop is done and we terminate that crop, so that my compost is out there, everything's in there ready to go come next spring when I'm ready to plant potatoes.

How has this affected your organic matter levels?

We've come up quite a ways. We used to be about 0.9% and we've peaked out at about 1.8%. And a lot of people hear that number and they're kind of disappointed in that. They would expect the organic matter to be a lot higher. But you have to keep in mind our environment. We do have very sandy soils. They're dominated with sand. We're also a very arid climate. So we just aren't ever going to be able to achieve these really high organic matters in this environment.

And what's really interesting is when you go around and start looking at the native soils in this area and start looking for organic matter there, it can be anywhere from 0% to 0.5%. So 1.8% is actually a huge improvement over even what the native soils can provide you with.

How has that affected your water management as far as irrigation? You mentioned something about how you cut down on a number of cycles and an amount of water. But has it influenced your irrigation in any other way?

I mean, just overall efficiency. The soils function with the water so much better now. I just don't feel like I waste a drop. I mean, I truly feel like the irrigation water I'm putting out there gets completely used, and at no point am I wasting anything. And like I said, you can really notice it when you compare my numbers to most of the other potato production in this area. I'm using a significant amount less of irrigation water, but it's not like I'm sacrificing anything else just to save the water. I'm still producing a very high quality and high quantity crop with less water, which just goes to show you how much more inefficient we were to begin with.

Is there pressure in your locale as far as amount to water depletion of water table, that type of thing, to become more efficient?

Yeah, absolutely. We sit on top of an aquifer, so we get recharge from the mountains each spring. When the snow melts it comes and recharges that aquifer. And then we pump from that aquifer. And we've depleted that aquifer to a level that it's a historic low. So I mean, water is the number one issue if you were to travel around talking to farmers in this area. If you were to ask them what their number one concern would be, almost every single one of them would tell you water.

When I was a kid, you used to be able to go out with a shovel and just start digging, and you could reach the water table. We're to the point now in my area, it's probably about 30 foot-- 30 to 40 feet deep. So we've depleted it to a scary level.

So now a lot of the talk is, you know, a lot of that has to do with we're in drought conditions. Were not getting as much recharge each year. But a lot of people think in order to bring that aquifer back that we need to cut acreage out of this valley. What I would rather see us do is improve the efficiency of our soil first, see how much we can save there before we start talking about actually putting farms out of business.

And that seems reasonable. A lot of questions about diversity. And you mentioned several times about you noticed the benefits, you noticed the changes. What was it that you were seeing taking place as you were adding the diversity that encouraged you so much as related to the soil there?

Yeah, I mean, just when we started bringing in the multi species green manure, I mean, that very next year it was just evident, just the potato crop that followed it. I mean, the crop was just so much healthier. The tilth of our soil, the soil was much looser. You could notice a difference in the smell of the soil. It had a more earthy smell to it. You could tell there was higher actinomyces activity in there based off of the smell of it.

And then like I said, when we first brought in the green manure crop, a lot of it was the initial water savings, because we were growing a shorter season crop. We weren't growing it to full maturity. So we could use a lot less water growing that crop.

But it amazed us how much less water we used the next year. And I think a lot of that just had to do from the root exudates. We added so much more carbon to the soil that we got the benefits of it the next year even in the potato crop. And now that we're going back and forth each year, we're getting in a cumulative effect to where I'm still seeing improvements in our soil. So we haven't even come close to

plateauing or peaking on our soil improvement. I think we've got a long ways to go still.

I had a couple questions related to your cover crops. How are you seeding them? And then again, what's your seeding rate, especially when you've got the more diverse-- what is it-- 14 different mixes? How do you even begin to figure that out?

We use the same drill that we used to use for planting our barley. The seed comes already pre mixed. We just dump it in there and go. And we're planting at about 40 pounds per acre, just because you don't want to waste money on too much seed, but you want enough out there to get enough competition with the weeds. So we feel really happy with 40 pounds per acre, but that's going to vary a little bit based off of your mix as well. And I rely a lot on Keith Berns there at Green Cover Seed. I sit down with him every year, we come up with a mix, and he gives me a suggested planting rate on that. And he's been spot on so far.

One of our participants observed that you use peas in all segments of your rotation there with diversity. Are you concerned a little bit about any of that--

Having the same crop every single year?

Yeah. Yes. Yes.

I'm really not, because we've got so much diversity out there. See, we've been trained in agriculture to not plant the same crop year after year, but applies to monoculture crops. You don't want the same monoculture after monoculture and monoculture. But when you've got so much diversity out there, it's not going to create those issues that you would run into by having a short rotation of monocultures. So I feel like by having a 10 species mix out there, I think we're getting the same value out of that in one season as you would a 10 year rotation with 10 different crops planted one after the other.

We've had several questions about late blight. a

Yeah, that's one of the-- you were asking me before we started, why is the San Luis Valley so good for growing potatoes? We are very fortunate here. We are technically in a desert. We get less than six inches of precip a year. And we just have very low humidities. So we just have an environment that isn't very good for late blight.

So in the history of potato production in the San Luis Valley, we've only seen late blight established

twice. And it took a really unique weather pattern to come in and sit into this valley for a couple of weeks to were it could thrive. But most years we just don't even have to worry about it, because you couldn't get it to grow out on those plants if you tried because we are so arid.

So it's an issue I don't have to deal with, but I know the guys up in Maine specifically and up on the West Coast, that that's a bigger issue. And I've had some conversations with some of those folks, and I don't have that first hand personal experience with late blight to be able to touch on that subject. But I think as long as you're following a lot of these fundamentals, I think that's the first step towards controlling it.

And let me throw this one at you, and maybe we'll wind up on this. In transitioning, Brendon, can you give some experience, what you did, and maybe some tips, if you were to start over again what you would do, and maybe make some recommendations out there?

Yeah, well, the trouble for us is this is about 20 years ago that we made this transition. And my uncle's the one that really led the charge on it. He just realized that what we were doing wasn't working anymore. But the trouble is we really didn't know-- we knew what we needed to stop doing, but we didn't know what we needed to start doing. So in our transition, it was very slow because we would try one thing, we bring in one tool at a time. We would see great benefit from that, then we would move on to the next thing. What can we do now? What else can we do?

So what's nice is we've kind of been the guinea pigs and we've discovered a lot of this on our own. But I've also been very fortunate. I've had access to a lot of tremendous resources across the country, and they've helped us bring everything together to where now if somebody else wanted to make this same transition, they could bring in all these tools at the same time, and they would shorten that length of time to make that transition.

Like I said, for us, bringing in one tool at a time, we really stretched out that transition time. But I don't think it has to be that way. And the more tools you can come in with at a time, the quicker that transition will be.

And it's really hard for some people. They see what we're doing and they say, well, that's great. And they want make the transition, but making it all at one time is kind of scary to them, because it's a completely new way of farming. So a lot of them just kind of want to bring in, well, let me just do this one

thing. So what I tell them is the more committed you are to making this change, the smoother the transition is going to be. So if you're only going to bring in 10% of my program into a transition period, only expect 10% of the results. Whereas if you can bring in everything all at once, you're going to have a greater chance of success.

That's a good way of a wrapping it up, Brendon. And again, I've got a few more questions here, but we are running over a little bit. I want to just tell you how much I appreciate your presentation. You definitely have an advanced level of understanding when it comes to the subject matter here, and I appreciate your effort there, and thank you again.

And with that, just remember to those of you who are interested in getting credits for participating in this, remember the process that Holli outlined at the beginning. And with that, we'll just call it a close. And appreciate your help there, Brendon. Thank you.

Yeah. Yep. Appreciate it. Thanks.