"Making soils data actionable webinar series. I'm Dani I am the senior soil scientist at the Washington State Department of Agriculture, and I am so excited to welcome you all today to talk about soils data. If you have been working in this space, you've probably noticed that more soil tests and data are available to farmers than ever. And while this can be empowering, it can also be confusing."
"New information on soil chemistry, biology, and physics can sometimes be difficult to translate into action. And so the Washington Soil Health Initiative has put together this series to showcase how useful and necessary soils data can be to making in-field decisions. Every Wednesday at noon this month, we will be showcasing projects from across Washington that are using real data to make real world on farm decisions."
"Today we have Troy Peters here to help us understand how to make soil moisture indicators actionable. Troy is a professor, scientist and licensed agricultural engineer working at Washington State University for the last 18 years. He has worked at the Irrigated Agriculture Research and Extension Center in Prosser. So for everyone in the audience, there will be a Q&A at the end, but feel free to post your questions into the chat as we go."
"You can find the chat feature at the bottom of your screen in a little thought bubble icon. Thanks for being here today, Troy, and feel free to take it away. Okay. Thank you. Hopefully, everyone can see me and hear me. Yes. Okay, great. okay. So, we wanted to talk about soils, and then in particular, I wanted to talk about how they can be used for, irrigation water management."
"so with that, I wanted to talk kind of the basics about the soil, water relationships. and, and then, so the two questions that we wanted to know, for irrigation water management is how when can I turn the water off? Usually people say, they want to know when they can turn it on and how long to leave it on."
"But in generally, especially in eastern Washington, where they just irrigate almost all the time. it it's kind of when can you turn it off and then for how long? And then, a lot of people are just kind of looking at the soil, kicking the dirt and, and making guesstimates or wait until the plants get water."
"They, they are visibly water stressed, and then they turn the water on. But when they do it that way, they tend to either cause water stress to their crops, which means they they cut their yield back. They're not getting as much, growth and production out of their crops as they would like, or they're over irrigating and then causing, resulting basically in, in a lot of deep percolation."
"so, what kind of data can we use for irrigation water management? So there's soil based, which is what we want to, focus on today, which is, based on soil moisture sensors. And then there's weather based, which is using, evapotranspiration, and crop coefficients, and I'll, I'll briefly cover that just for, for information. And then there's plant based methods which use sap flow gauges and stem relief water potential."
"and, or the canopy temperature can be used as a, as a indicator of,

plant water stress. so I'll also, talk about that briefly. So soil is basically little bits of rocks and and so and then, you know, because they can't compact this, those rock completely. There's little gaps in space in between the rocks where all the action happens."
"if that all that space between the rocks is filled completely up with water, we get mud, basically. And that's called saturation. So that means that all that the soil is saturated, we can't get any more water in the soil than that. however, if the soil is left to, to its own devices, the excess water will kind of, be pulled out by gravity."
"And it comes to a spot where the, the soil is able to hold on to that water. against that pull of gravity. And it has to do with a couple things. So water is a polar molecule. It has the two hydrogen atoms are on on one side of that oxygen, atom. And what that means is that it has, a, a positive side and a negative side."
"So the positive side of one molecule sticks to the negative side of the molecule, which sticks to the positive side of one or other, other molecules. And so it kind of tends to clump together, which is why you can see, you know, water droplets, will they coalesce? Why, if you sprinkle water, on the table, it'll group up and it'll pull into a bubble into a, into a droplet."
"this is why, water sticks to your body when you when you take a, a shower or something, you need a towel to dry it off. and actually and so and and but so it it, the molecules stick to each other, but they also stick to other polar surfaces. So think about when you're drying your hands off or or, after a shower or something, you're drying yourself off with a towel."
"What it's doing is that water is sticking to those fibers. and then it's pulling the other molecules in behind it. and it pulls that water away from your hands. and that's how it dries you. So this is the exact same mechanism that soil uses to hold water. It holds on to those soil particles, and it pulls the other molecules in behind it."
"And it, allows that soil to hold on to water. So the maximum amount of water that soil can hold long term against the pull of gravity is called field capacity. So field capacity isn't. I mean, you can put more water in the soil than field capacity because it can go up to saturation. But field capacity is the maximum amount of water that that soil can hold against gravity."
"So, once but the, the soil, the roots can pull the water away from the soil and absorb it up and, and use the water, or that water can be evaporated from the soil surface and that reduces the water. and it'll come to a point where there's still a little bit of water left in the soil, but the, the plants just no matter how hard they can, they pull, they can't get that water away from the soil or the the water is held in such little tiny cracks and it's really far away from, you know, far meaning, in relative terms to the tiny root hairs and soil particle sizes."
"but far away, so that it just can't get that water away from the soil. And then the, the plant can't get any more water and it will tend to die. So this is permanent wilting point. So even though there's water left in the soil, we don't want to get to the permanent

wilting point. So this means that, between field capacity and this permanent wilting point, this is the point."
"This is the the water content that we want to manage. for, for plant growth. if you continue to dry that soil down, if you put it in an oven and you cook it off and make sure that there's no, water left at all, it gets to oven dry. however, that water here is unavailable."
"So this is, available water again. This is what we are interested in. So, the available water, this is kind of in this case, we kind of in two dimensions here. We say, okay, that's the width of this bucket. And then the and then we also have the root zone depth. So the deeper if I have a the tiny newly planted grass seed then my roots depth is really shallow."
"But as that as the roots grow and grow it has access to more and more soil. And so basically the the size of that bucket gets bigger and bigger and bigger, and the amount of water that the soil has at the plant has access to in the soil, gets larger. So the water holding could opacity of the soil is the, the water holding capacity of the soil times the root zone depth is the size of this reservoir."
"So this is kind of in this two dimensional bucket here we can see this is the size of this bucket. If you can't, if you put more water in the soil, it looks like I mean, it makes you feel good. I mean, the water goes in the soil, but if the soil can only hold so much water, and if that water, that water will keep going."
"If it's at full capacity or exceeds full capacity, that water will keep moving down, and it can move down past the bottom of the root zone. And, that water is lost. So you waste you wasted your time and energy and money, and also you probably rinsed out a lot of nutrients out of your soil when you did that."
"So that's not a good thing to over irrigate. So in this case, in our little, example here, this is where overflowing the bucket, you can definitely overflow the bucket. The buckets only so big eat, which is water out. That's how the water actually comes out of the top of soil. But this is the evaporation and transpiration, which removes water from the soil."
"Water holding from that reservoir. And so, in order to do, water management for crop growth, we need to know what this soil water content is. And so there's two ways to estimate this. One is we can get an estimate of how big this bucket is and then try to keep track of it and say, okay, every day if we got this much water out."
"And so our water level, we're basically modeling where, how the, how that water level drops in the soil. And then we keep track of how much water we put in and when we put it in. And then we can use that as kind of the checkbook, which okay, money out. And then money in is same as water out and water in to do water management with that."
"so of course different soils hold different amounts of water. And this has to do with, the locations or how water is held by soil is primarily held in the spots where the two soil particles come together. So, if you stick your finger on water or on the table, you can see that it sticks to your finger and also sticks to the table."
"And then there's, there's the meniscus or the the point where the two

come together, is, is where a lot of that water is held. So, in other words, the more spots in the soil where the, the, the soil particles are coming together, generally the more water a soil can hold. So if you extrapolate all the way up to like a bucket of gravel, you know, and then you put poor water in that, of course, the water goes in very quickly because the poor sizes between those gravel particles is very large, goes in very quickly, but it goes right out the bottom."
"And, if the bucket has a hole in bottom, obviously, and it goes right out the bottom and then it still holds a little bit of water because the gravel is wetted and then the, the spots where those, rocks come together, it can hold it there. but just not very much. And so this is the same with a coarse sand and fine sand."
"The smaller the particles, the more of those sites where those two soil particles are coming together. And that that's more it means it can hold more water. And when we do, irrigation, water management, we like to do things in terms of one dimension. so just like when we measure rainfall and snowfall, you just do it in one dimension, okay?"
"We had three, you know, a half an inch of rain. We do that. Same with, irrigation. We have a half an inch of of water was used. Okay, let's supply a half an inch of water to put it back. And that gets rid of the the size of the field and allows us to kind of make it a little bit more universal in terms instead of thinking of things in terms of volume, think in terms of one inch, or one dimension."
"So one way to, the water holding capacity and an easier way to think of that. Two is the inches of water that the soil can hold per foot of soil depth. So inches of water that it can hold between full capacity and wilting point per foot of soil depth. So like a silt loam soil or something, you know, about two inches of water, per foot of soil depth."
"it's kind of a rule of thumb. Sandy soils are going to be about one inch, so about one inch of water per foot of soil depth. and it just means that these going to have smaller buckets. Right. and the other thing to, to notice here is look at the range 1.8 to 2.8. That's huge."
"And that's because it's not just the soil texture or the size of the soil particles that matter. Soil structure also matters. And how much organic matter is also in the soil. Can can affect, how or tillage. And things you do with the soil can affect the water holding capacity of that soil quite a bit. and so, that's just something to think about."
"Even, you know, you're kind of stuck with the soil. You have, you know, at least in agriculture, you are, but you can change that by managing it to increase organic matter content to, to to do things so that you don't consist constantly to destroy that soil structure. And you can increase that water holding capacity. So one thing to so if I have a deep soil or a deep rooted crop and I have a silt loam soil, then I have a large water holding capacity, I have a large bucket, I have a deep soil same, but it's a sand."
I have a smaller bucket or a shallow rooted crop or a shallow soil. Maybe it's just rocky down here and there's just not much soil there.

Then I have a smaller bucket and then a shallow sandy soil. Here also is the smallest bucket of all. The thing to pay attention to is the amount of water that that crop needs to grow to be healthy and happy does not depend on the soil.

"It it is going to be the same regardless of the soil. So a common misconception is, oh man, I have this shallow sandy soil out there. I see water stress in there all the time. So what I'm going to do is I'm going to put it in some extra big sprinkler nozzles in that area, or I'm going to double the amount of drip tubing."

"So when I apply the water I apply twice as much water. So I just put more. I really got to pour the water to that shallow, sandy soil so that because I always see water stress, I must need more water. wrong. The problem is you run out of water very, very quickly. it's not using more water, it's just running out of water more quickly."

"And so you need to water less, but way more frequently, you know, twice as often, half as much or, in order to, make sure that it doesn't run out of water before, before it becomes water stressed and then you're filling it up. And when you fill it up, you're not overflowing the bucket. If I apply twice as much water here, all of the extra water that I apply is going to also be lost to deep percolation, or it's going to be throwing good money after bad."

"to me to try to fix that problem. the other thing to pay attention to. So here's fuel capacity. So this is the full soil long maximum amount of water the soil can hold long term against the pull of gravity. Here's dead plants. Don't want to go here. as you dry it down, it's easy for the plants to get water away from the soil."

"And it doesn't hurt their production at all. But after a while, the plant starts to struggle. It can't get the water away from the soil at the same rate that it needs it. Or, it's just. And so the plant starts to shut down, curls its leaves, closes a stalemate. It's, trying to limit its exposure to sunlight and energy so that it reduces the rate that that water, is lost as a way to protect itself."

"And so we we we lose this maximum production, but it also reduces the water use rate, but it also reduces the yield of the crop. So what we do is we pick this mad maximum allowed little depletion. We say okay, at this point we're going to begin to see water stress. And so we don't want to go below this point or in some cases you do."

"And you're like growing wine grapes where you're deliberately, imposing water stress. And then you're you're over here on purpose. but, generally people, want to keep it between field capacity and this mid line. And 50% is kind of a rule of thumb for many crops. Not all, but many crops. as, as the, the water, how much water you can deplete of this total available water holding capacity before you're going to begin to see water stress for that crop?"

"some crops, like alfalfa, are very water stress tolerant. And they can you can deplete, you know, 60 or 70% of the water. Some crops like potatoes or onions are not very water stress tolerant. And you deplete like 30% of the water and begin to, to, show water stress. So soil moisture sensors. So, this is the best way that we know of to know how much water is in soils that we can use for irrigation, water

management."
"and so is because we just measure it. first of all, where do we put them? so, well, things we don't want to do is put them right at the edge of the field because crops at the edge of the field are doing funny things. Sometimes if they're right at the edge, then they're getting water from underneath the road or whatever."
"They're next to you that doesn't have crops pulling the water out from there. And so they grow more vigorously or sometimes, because the, the hot air is coming across this, this arid area and then it's, hitting this the edge, the, the, the crops right at the edge of the field. And so it uses more or less water."
"in other words, it's not representative of the field. So you don't want to put it right at the edge of the field. You want to put it in a ways to where it's, representative of more of the field. And then it depends on what you want to do. You can either choose the average soil condition. And so if you have all these different soils in your field, maybe you would want to pick okay, this is kind of an average condition."
"So we'll put it here. Or if you just say, hey, I want to make sure that I get the best yield everywhere. And so I'm going to put it in this soil, and I'm going to irrigate such that I irrigate before this soil experiences water stress, and I irrigate in such a way that I don't overflow this soil."
"And then the rest of these soils are going to be fat and happy. They're going to be fine. They're also not going to seawater stress. They're also not going to see water, water loss to deep percolation in those soils. so it kind of depends on what you're trying to do if you want to maximize yield everywhere. This is where I would put it, the lowest water holding capacity."
"So if you're kind of doing, things with deficit irrigation and and you just kind of want to look, see the average soil condition, then you, might want to put it there. Then at the depths, let's say if I have one sensor or I had two sensors or three sensors, if I have one sensor, I kind of at the depths."
"If I only have one death, then I would want to put it in the active root zone. So obviously most of crop roots are at the top near the, you know, near the soil surface. And then as it goes down you can find trace, roots way down deep. But most of the most of it's up here. And so, the rule of thumb is if you divide the crop, root zone depth into quarters, then 40% of the roots are in the top quarter or 30% in the next quarter."
"20, ten, 40, 30, 2010. If you add those up, it's 100%, in that, but again, most of them are at the top. So if I have two. So if you have one sensor, you would want to put it there in the middle of that. two sensors. You want one in the middle. That will show kind of a lot of the soil water dynamics and how that changes drastically over time."
"But this sensor down deep is going to give you a lot of information. What it's going to show you this. If I irrigate and every time I irrigate, this sensor doesn't move. What does that mean? It means that the water I applied never got down there. That's interesting. And

that's relevant if I irrigate and every time I irrigate or every time I have a rainfall event, this sensor, it lights up, lights up, goes up, and you see that water go past."
"That means I'm putting too much water on so that that, sensor down deep is also interesting and relevant. and so if I was going to pick one, putting one down at the, toward the bottom or even, you know, right at the bottom of the root zone is going to give you a lot of information that's going to be useful for you."
"and then if you have three sensors or more, you just kind of divide that up, however you want to kind of represent that whole profile. and let's talk about the different types of soil water sensors. So these measure tension. So there's two things we can measure the soil moisture sensors. One is soil water retention, which is how hard the suction that the water that, that, the soil is pulling on the water."
"So if I have water and I put it, in my hand and I take a dry rag, I can suck that water up off of my hand. It pulls it out. and so, that that cohesive and adhesive forces between the, the water molecule holding on to the soil particle and then pulling its bodies in behind it, it's a suction."
"And we can measure that suction directly with a ten ammeter. And here is a ten kilometers. And this one has a broken tip, which I like actually, here's one out of broken tip here. I like it because it shows you what is inside. And so basically this is just a porous ceramic material. And, we fill this up with water."
"Oh, man. I need maybe ten of these. Anyway, I'll try it. Just put it in front of me. The fill it up with water. And then when this gets, full of water and I bury this tip, it gets in contact with this soil surface and the soil that soil water tension falls water out of this, out through those pores in that tip."
"And because and when this is full of water, the it can move water through it, albeit slowly. It can move water through it. but, the pores are so small that you can't get air bubbles in there. And so it'll pull water out of this and create a vacuum in here inside of this tube. And then we just measure the vacuum right here."
"this is, a vacuum gauge, that we use to measure the vacuum. and a bar is a unit of pressure or vacuum. About one bar is equal to about 14 p.s.i or one atmosphere. and, 100th of a bar is a scent, a bar. And that's the, units that are most of these are measured and sent to bars, 100th of a bar, which is a measurement of vacuum."
"So good thing about ten kilometers is it gives you that soil water tension in the soil water tension is the same force that the, prop has to overcome in order to pull that water away from soil. So that's relevant, to the crop. these are less expensive, although not inexpensive, just less expensive. I haven't priced them for a while."
"I guess I would estimate they're probably 70 to 100 bucks each. I have no idea. widely used, studied and accepted. And they're not affected by salinity. So a lot of these things that are measuring the electrical properties of, of soil and, are affected by the salts in the soil, but this is not, it samples a fairly small area because it's just kind of what's around the tip."

"and then it indicates when to irrigate. So that's the soil water, the plant water stress. And it can't really tell you how much water to apply. So if you're using tension, tension gives you wind volume. If you're measuring the soil water volume, which I'm going to talk about in a minute, that shows how much you can use that to indicate how much water to plant."
"So another sensor is is a resistance sensor. That's this one here. this is a, it look like this. basically it's got two conductors into it in a piece of gypsum. Gypsum is the same stuff that's in wallboard. The most of your the insides of your homes and offices and stuff are made out of, and it measures the resistance between those two conductors that are stuck in that piece of gypsum, water conducts electricity."
"And so, the more water that's in that piece of gypsum, then the less resistance that there is between those two conductors. and then and, and, and in this case, this one has that same piece of gypsum in there, but it's kind of encased in sand. And they do a lot of things to try to make it so that, to increase the, the area, the soil that it's exposed to and to make it a little bit more uniform, uniformly packed around that, sensor that's in the middle in order to, decrease the variability between these sensors, there's still kind of a lot of variability between them."
"like in another, they put one here and put one here. They might be different numbers, but I'll talk about how to deal with that in a minute. resistance sensors. So, these are inexpensive. They give, also usable trends. they give the soil water potential again, that's that tension. and it's easy to log data because you can wire them up to data loggers, and it can be wired up to telemetry, and it can be, you can look at it on your phone if you have all that set up that is affected by salinity because, of course, salts, help water to conduct electricity and then which will affect the resistance"
"between those two, conductors. And so, it does give imperfect accuracy, in other words, just to repeatability is kind of, difficult. And then samples a small area. And here's an example of a water meter that you would use these two alligator clips to clip onto the two leads that come out of that. It measures that, resistance and then applies a polynomial to convert it into cell water tension incentive bars."
"In this case, it's reading 25 sandbars. So what do we do with these types of sensors. So as a as a starting point, 30 to 50 sandbars, of tension is usually a good point for to irrigate. So if it so low tension, which means if it's zero, it means the soil is full of water. And if it as the tension increases, it means that it's drier and drier."
"So the high number is bad in this instance, at least, if you're trying to impose water spread or trying to avoid water stress. and a low number is is for so 30 anything above 30 to 50 sandbars is the irrigation for no stress. And then increase that to 80 to 100 sandbars for higher or imposed water stress."
"and then what we do is because maybe there's the repeatability

issues, etc., then you just correlate those numbers to a proper condition. so I go out there and I'm looking at my, my sensor and it says 50 cent of bars, but I'm looking at my crop and it looks like it's water stressed. Then I say, okay, if 50cm is not my number, I want to irrigate at 30."
"I want to irrigate before it reaches that, number in the future. And then, you know, three days from now, it's 20cm. And I say, okay, and it's dropping, so it's getting close. You can get an idea of when to irrigate. based on that. and then that watch that deep sensor after an irrigation to indicate that degree of, the depth of penetration, how, how deep the water went."
"So here's what, the soil profile might look like in this case. So, the soil water content, the soil water tension increases. They built the graph upside down, which is you can do it either way however you want. But they did it as a tension. So a tension is a negative suction. So they are negative pressure. and so they just did it negative which is fine."
So you can see that the red one is probably the shallowest because it gets driest the first and the pink one is probably the deepest soil moisture sensor the irrigate. And you can see all of those sensors moved which means they may have over here engaged. In this case they went all to zero. Go back down up to zero back down like this.
"So, anyway, you can use those numbers to kind of give you an idea of what's going on. Capacitance probes here is this one is a capacitance probe. It looks like this. and then the a lot of work along similar principles in this case, this sensor is placed in the soil. And what it does is it measures between these two conductors."
"it's measuring the capacitance. So the capacitance is an electrical property of all materials that indicates how much, electric charge that it can hold. It's the key factor, if anybody knows anything about, electronics. but it's an electrical property of soils. You can measure it using variations in frequency across those, to conductors. and that's a function of the volume of water that's in the soil."
So these are measuring soil water volume. So you can do them different ways. This one is like this. This here. And then as you put.
You can pull it out. And then these are these sensors that are in there. And again it's just measuring the capacitance between these two conductors as it's contacted with the soil inside of here. It's measuring through this plastic and into the soil. And then this is installed into the soil. One thing that's of interest is the end of this.
"this is a sharp cutting edge because any gap between this sensor and the outside soil can cause, quite a bit of variability in the readings. And this is kind of a major weakness of capacitance probes. I'll talk about that in a second. Here's one. In this case, this one slides down a tube, which is the way that this is meant to, you know, you slide it down a tube and then you take different measurements at different depths."
"You and then you move it to next to you and you slide it down, etc.. So what happens is this measuring the capacitance between these, these

two conductors in the soil. And of course it's going to measure. But if what happens is that although, you know, if the soil was completely dry and I brought a wedding front near it, I would begin to see that these numbers start changing, maybe about this far away from that sensor."
"But in reality, what it's super sensitive to is what's happening right here, like within a couple millimeters of that, of that, these two conductors in the soil. So if I install that wrong, there's a gap between that sensor and the soil around it or, you know, all right, wiggle it or, you know, a worm goes by or something like that, it's really going to affect, that reading quite a bit."
"so good thing about capacitance sensors, it gives that soil water content or volume of water that's in the soil. And it's easy to log that data. again, we can hook it up to electronics and make it work that way. It samples a fairly small area especially. It's very sensitive to what's immediately next to that sensor. So installing it, properly is really important."
"And it's not always easy to do. it can be, expensive, because in this proper installation is critical, and it is affected by salinity and temperature, because both of those things can affect the, electrical properties of the soil. time domain reflect miter is another way to, measure soil moisture sensors. So water here is one."
"Actually, that is, uses the same principles, but what it's doing is it's measuring how, how fast a, a pulse comes down and it gets reflected off the end of that, wire and it gets, measured, in this other wire. and so how that works is fairly complicated. and it uses fairly sophisticated electronics."
"Look at so what they're doing is they're measuring the scale of this electrical pulse as it goes down off the end of that thing. And look at the ten to the -12 seconds. So if you know -12 which means it's smaller than micro smaller than pico. It's measuring the electrical on a very, very tiny, time scale and getting the exact, look of this, a profile."
"however, they've worked out a lot of those. And then the course of time to time domain reflect cometary sensors is is going down. So, actually, so actually more and more sensors are using that same principle. Here's one, they also call it time domain transmitter, which is kind of similar. You can if you're really interested, you can dig into the differences with that."
"and well, so these sensors give the volume of water in the soil and the problem is so it, you know, you get a number, let's say it says 35%. What do I do with that? What if it says 38%? I don't know what to do with that. So in order to and because that number is going to be different for different soils, we just talked about how, sandy soil doesn't hold as much water as Sloan soils and, and how soil structure can, can and organic matter content can affect the water holding capacity of soils."
"So these numbers are relative. And so because they're relative if it's wrong, in other words let's say I don't install it properly. Exactly right. It's still relative. As long as that that number can

changes and it doesn't, exhibit hysteresis, which means the wedding cycle, when it comes back to the same spot on the drying cycle, it gives you a different number."
"then it's still usable. And so what we want to do is we want to know two things. We need to know what field capacity is according to that sensor, according to that soil, where it's and where it is installed. So we need to know that field capacity or that full point. And the easiest way to do that is just, irrigate, put a lot of water on."
"And as soon as the soil thaws or after 20, 24 hours after having irrigation, let that water, go through. And then the soil should be at field capacity. By definition, it's holding that water long term against the pull of gravity. just to note, it's easier to do this in the spring when it is almost zero or it is zero than it is, during the season, because the constant movement of water in and out, because of it, moves that number so much that it's kind of hard for a field still long enough for you to say, okay, that's field capacity."
"So we need to know what field capacity is. And if we know what field capacity is, then the difference between a current reading and what field capacity is. That is what our soil water deficit is. and then the other thing we need to know is what is that mad point? When it when is it going to experience water stress?"
"And a rough rule of thumb is that if we go all the way back to, the, the, this the permanent wilting point of a our soil is, about this this permanent wilting point is often it's about half of field capacity in general. This this graph. I need to fix this because it's usually up here. It's about half of field capacity."
"And what that means. And if I choose my mad point to be half of that, then half of half. And so about 75 to 80% of the soil water depletion, will give you, a rough or of the field capacity, not depletion. So let's say field capacity is 40%. That means at 30%, which is 75% of 40%."
"that is where the, you might be a good idea to do, that and then, and then you do less of that for vegetables. And then again, what we want to do, because those rules of thumb don't apply for everything, especially for sandy soils. that doesn't work. But you can use table based values for that water holding capacity on the soil and say, okay, sandy soils use."
"You know what this is? Here's my field capacity. And I looked at it from the sensor and the the value that comes from the sensor is actually the most useful number because, we don't know exactly what it is. because most people don't test what field capacity is for their soil. They just look at the sensor. And if that sensor is installed a little wrong, it's still okay and it's still usable."
"Because what we want to do is the difference between that field capacity and current numbers, the number we're going to use. And then we say, okay, the water holding capacity. And then 30 to 40% of that for vegetables and then 50% of that for other things. and then we refine it with our, with our experience, we see, oh, I thought it was going to begin to experience water stress at 25%."
"It's at, 20%. And it's still fine. It's not happy. Okay. We revised

that, based on our visual observations from the field and, other things. The other thing we can do. So here is the soil, water content over time. This is for a, soil volumetric water content sensor. So this is just one sensor, a couple things you can see."
"This wavy line happens for a couple reason. One is this is one, the sawtooth, period here is about one day. So during the middle of the day, that's when it pulls water out of the soil. And that's when it's going to drop. And that either comes up, at night because the soil is redistributing water to those drive areas."
"In other words, it's moving it back into those areas that it was pulled out from, by the plant, from areas that have more water or this sensor is temperature sensitive and the temperature swings from day to night are causing that, that to move up. We're not quite sure. The other thing that happens. So here's here was a rainfall event."
"Here's that irrigation event brought this a of content up, brought it up, brought it up here. This is interesting here to me because it went up but came down quickly and then it and then it came down. So to me this means that this happened, because we exceeded field capacity, it was that saturation. And then this decrease in the water content was because that excess water was just draining through the profile at that time."
"So we can exceed field capacity with our irrigation events, but we don't want to irrigate to that point. So in this case, they drew in the blue line here as field capacity. But I would probably move it down to here about 12.5. And then my current if I want to here. So if this is today I want to irrigate."
I look at difference between here 12.5 and my irrigation 11.50 okay. Put on one inch of water.
"here's some other examples. I'm kind of running short on time, so I should speed up. And then the look and feel method, which is the the good old, you dig soil up and then you look at it, you try to form a ball, you try to push it into a ribbon. You see kind of how the soil, adheres to each other because, water helps the particles because that adhesion and cohesion between the water also causes, the, the soil to be, to kind of stick together as well, which is why wet soil you can form into a ball, you can sometimes push it into ribbon, you bounce it on your hand,"
"it'll either fall apart or it'll stick together. You can use that type of experience, the look and feel method. it's it's definitely a subjective, way to do it, but you can get better at it with time for your particular soil. And then what I would do with this is do it the same way. Take the time and experience to train yourself to do it correctly."
"The two things you need to know is what is fuel capacity? When does it look? What does it look like and what does it feel like when it's at field capacity and you need to know what it looks like and what it feels like when you begin to experience water stress. So dig up some soil. When it's a fuel capacity, look at it, feel it, feel it, bounce it around, dig up some soil."
"When, when at the first time you ever see water stress, look at it

and feel like it. Feel it and say, okay, I want to manage it between those two points and so you can do it with this look and feel method. If you're kind of systematic about it and you, train yourself. The other thing is, I mean, going, you know, 6 to 8in is not a big deal, but a lot of times getting soil from, you know, three feet deep, you know, people don't want to dig holes that deep."
"So you need to get a soil probe that allows you to pull, soil from those deeper depths or, or, figure out a way to not just look at what's happening at the top part of the soil, but the entire roots. so one thing, I wanted it. So neutron probes. I didn't talk about that because they're kind of mostly a research tool or consultants use them."
"Sometimes they they do give you is a different mechanism and it gives you the most correct answer. But most people can't don't want to manage the paperwork and, and dealing with a radioactive device. And so they don't use those. So but most sensors will give you a trend that's usable for irrigation scheduling and then proper installation of those sensors, is critical and must be done right to give you good data."
"And then actually using the sensor is important. People install them and then they kind of ignore them, which is, unfortunate. And then the other thing is, is to keep records and calibrate yourself using numbers that crop response and your experience. So, like I said, you can you can get better at it over time. And then if you, there's consultants that will do this for you, you hire them, you ask them a lot of questions."
"You, and then you eventually you might not need to pay them in order to, get the answers that you want. So, with that, I am going to stop sharing and answer questions."
"Okay. Thanks so much, Troy. we have 11 minutes and 13 questions, so I've tried to kind of rank them based on their applicability to the most people. so from Savannah of South Yakima Conservation District, we want to know how many sensors do you need for a field? And does that depend on soil type and acreage? What is your advice?"
"because of the price, I can just tell you what most people do is because of the price, of them, most people use, just one."
"And then so in science, too, we say, if you only have one sensor, it's right. If you have lots of sensors and they're different, nobody knows what to do with those. And so, that's what I would do is this one, and in fact, I would, I would do it at two, two depth and in one location, per field, if I was managing it for it was my money and it was my field, and that's what I that's what I did."
"And I get one at the deep point and then one in the middle. That's a great transition to some questions we have about return on investment. So from your perspective, is there a good return on investment for installing these? And do you know if there are studies or data available about the ROI? yes. So and the answer is it depends on what you're growing, honestly."
"So, some crops are very sensitive to water stress and so and and and yield and quality drive the ROI numbers like nothing else. so if I

have a field, pivot full of potatoes and I get it wrong, it hurts a lot. But if I have a pivot full of alfalfa and I get it wrong, maybe it's not that big of a deal."
"so, primarily the ROI is strong for vegetable crops and not so strong for a low value like, forage and grain crops. Honestly. Okay. And someone had a question about the sensors in fruit trees, so maybe you can talk about that. And, and more broadly about, just sort of annual versus perennial. Sure. So, annual crops are great with soil moisture sensors because they, you don't have to dig them up every year with, print with I mean, that I say with perennial crops, you don't have to dig them up with annual crops."
"You do, you have you have tillage. That and the sensors are in the way, and especially if they're in forage crops and you're trying to drive around with harvesters and things, but, in, perennial crops like tree fruit and grapes and hops and things, then, it's great because you just tie them to a trellis wire or, or a pole or something, and it's there and it's out of the way, and you can keep using it."
"also, annual crops have a growing roots. so that the, the bucket depth gets big and then it goes to zero, it's big. And then, perennial crop has fairly static roots, depth, which is also useful. so that strengthens the ROI for, perennial crops. Also perennial crops like apples and pears and cherries and, and, grapes and stuff."
"The the economics are tend to be stronger for those, you know, your, your penalty for messing it up tends to be higher. Also, water management affects a lot of diseases like caulking. And, what's the caulking in, pears? bitter pit, things like this. So there's, there's strong economic incentives to do it right for those."
"Thanks. so once the sensors are installed and you touched on this a little bit throughout your presentation, but, how easy is it to interpret an action on the data they collect? And maybe you can talk even about some of the web based or app based data portals and how tech savvy you need to be to use them."
"Yeah. So, so a lot of the sensors, you, a lot of people purchase them from, dealers like, William Wilbur Ellis or Simplot or, there's a lot of companies like Irsa, that will install these for you. And usually what they do is they set up, set it up with a telemetry system where there's a cell phone modem on the system that's out in the field, and it's it's reporting the data to the cloud, and you're getting it on your phone and you're looking at it."
"and then all those apps and stuff look different. and you just kind of have to, train yourself to, to, to use those, but so that that telemetry system obviously is going to cost you more than if you kind of, put them in yourself and you just go read it with alligator clips or something like that."
"but, you know, it's you don't have to go out there and do it, so maybe it's better. It's worth it for some people. It's not for others. Okay, so six minutes left. Lots of questions still, very popular topic. Maybe. Well, okay, so you showed us a lot of options, and you discussed the pros and cons of various options."
"if you were about to invest in this technology for your farm, what

kind of sensor would you choose? for? You know, if it was my money, I would do, The other thing is, I want it to stay in one location, for a long period of time. Because it wouldn't if I because a lot of it kind of a relative number that I calibrate myself to over time."

"And if I dig it up and move it all the time, then I have to redo that. So I would want it to stay in one location for a long period of time. And, so I'd want something that was robust, and could stay there. I would use volumetric water content, something like a capacitance type, probe."

"and, I think I wouldn't worry too much about, what type of sensor it is, but, just more, and I would use two sensors, you know, again, in the middle or the top third of the zone, one down at the bottom. And then, yeah, I think I would probably pay for the toy monetary system just because I would."

"It would be nice. I can check it every morning. Okay. And we have some really interesting questions about AI or artificial intelligence. So maybe you can talk about, what advancements you anticipate in this field in the near future. And if I has a role in this space. Yeah, that's a great question, one that we are actively working on, which is using AI to help interpret the soil moisture sensor signals and data so that it really is plug and play."

"I talked a lot about, okay, the kind of the mental thing you have to work out to interpret that, the sensor signal and in comparison try to figure out where field capacity is and, and where your water stress point is. We think that we can use AI to, develop these automatically and so that it really is plug and play."

"and it just gives you okay, today's soil water deficit is, 1.5in. So if you're going to irrigate today, that's how much water you apply, without them having to. Okay. It's 37% male capacity is 42%. You know, all this stuff. So we think we can do that. Awesome. okay, so I guess unfortunately, this is the last question."

"So really apologize to everybody who's questions we didn't get to. but if you were trying to increase soil, or when trying to increase water holding capacity by increasing organic matter, is there a point at which your soils sort of have a limit or can you exponentially and linearly, continue to increase water holding capacity? you know, this is very popular in the soil health space."

"And yeah, you know, that's I it's probably a question for Danny, actually, I, I don't I, there's definitely a limit, but, yeah, you what do you say? I think there's definitely a limit. Organic matter. accrual is important. And that can be done to an extent with management. And that can to an extent increase soil water holding capacity."

"But there are definitely like textural and and climate limitations. but you are the pro here. So we actually do have two more minutes and we're going to okay ask another question. so maybe, the last, question I know a lot of folks have kind of low, quality irrigation water or salt affected soils. Can you talk a bit about the effect of salt on water holding capacity?"

"Sure. So salt, plants, have membranes on the roots, and they pull

when they pull the water out of the soil, they leave salts behind and then salts. You know, if you have high salt on one side of a membrane and low salt, it creates an osmotic potential, which means that the clean water wants to move over to the salt area, which means that it's it's harder for the plants to get the water away from a salty soil than it is."
"a clean, clean water in the soil. So, and, what happens? So any water, if you have irrigation water, that salty, that little salt build up and build up over time. And, just the simplest way to do it is you deliberately over irrigate and you rinse those salts down out of the root zone and pushes them deep and delays the problem for some later date."
"But it's it's delayed, and there's really no way you can take the salt out of the soil. But I know so. Okay, that brings us exactly to 1:00. Troy, thank you so much for all your expertise and for this presentation for folks who are interested. We do have our final webinar in the series next Wednesday at noon. That is going to be specifically for users of the R programing language."
"So if that is not you, the talk may be a bit technical. but otherwise please join us to learn about auto generating soil health reports. And thank you again, Troy. This was awesome. Thanks."