

>> JENNIFER RYAN: Okay let's get started. Greetings, welcome to today's webinar entitled organic soil health practices for water management and water quality. My name is Jennifer Ryan and I'm a natural resources specialist for the natural resources conservation service's, East National technology support Center. I will be your host.

I want to take a moment to remind participants that these tradenames during our webinar is for information purposes only. Two other tradenames does not constitute a guarantee of the product by the US Department of agriculture. Nor does it imply diversity by the department or the natural resources conservation service is over comparable products that are not names. With that we will begin.

I would now like to welcome Mary Hathaway our moderator for today.

>> MARY HATHAWAY: Thank you so much for my name is Mary Hathaway and I am the research and education program manager with the Organic Farming Research Foundation. Today I am pleased to introduce Mark, Mark Schonbeck who has worked for 35 years as a researcher and advocate for sustainable in organic farming. He has worked as a research associate with the organic farming research foundation to develop research-based education materials including a series of practical guides on soil health organ informing. He is a wealth of knowledge. We are excited for him to present on soil health practices for water management and water quality. As part of the seventh webinar in this series. Mark please take it away.

>> MARK SCHONBECK: Thank you and welcome to the webinar. It goes without saying that water is essential. We cannot grow crops without it. If you have too much at once it could create a crop failure. The question is whether organic soil health practices could buffer the farm against the impacts of drought and deluge? And also make the soil more efficient and absorbing, holding, and providing moisture to the crop.

It is interesting to contemplate the effects of weather extremes, drought and excessive rainfall. Not only on production which we are familiar with but also on soil health itself. When the soil is dry, plant growth slows down, microbial activity slows down so the biological processes that regenerate soil structure and soil organic matter, are hindered. Those processes are vital for maintaining the soil capacity to absorb rainfall and to provide moisture to the crops over extended periods of time. Of course dry soil condition could increase the risk of wind erosion and wildfire.

If it rains too much, it could take nutrients out of the field and effects water quality. It increases water erosion. It also may damage the soil structure and plant roots. It can increase plant root diseases and damage the plant health.

There is an example on the right-hand side is an orchard which is with standing water after a heavy rainfall, and we'll talk about more about why a few inches of rain can create a severe impact on the California orchard.

There are challenges associated with urination, of course it is essential if you're going to grow vegetables in an area that has ten inches of rain a year or not you will need irrigation. Will for production because you have risks of depletion of aquifers and rivers, water resources. There could be nutrient losses if irrigation is greater than the soil could absorb any of tale water or drainage water. So when

using groundwater sources especially in our region or high tunnel regions, you could build up salinity in the soil.

So a lot of this is going to be review for you and the next few slides I will not spend a lot of time on. In fact I learned some of this from NRCS resources myself. So of course when happens when it rains it first the rain if it is heavy, if it is a soaking rain, the rain fills the water pours and then is a moving waterfront goes down to the soil. Then the largest pours drain out under the force of gravity, and the smaller pours the capillary pours, doused the moisture retain at the capacity. The smallest pours hold what is called hygroscopic water which is not available to plants. When you're down at the hygroscopic water of the plant growth stops and the plant wilts. The inherent soil properties, has air-filled available water in the hygroscopic water and another one a key and here property is the depth of the root. How deep can those roots go to absorb moisture? And also how well does the soil absorb and drain out after heavy rainfall?

The soil texture has a significant influence. So Sandy soil, a larger percentage of the volume of the soil is solid, but a lot of it is large pours and become air-filled as soon as the water drains out. So the available water holding capacity is limited. A loamy soil is ideal. With the silt fraction and the aggregated clay and topsoil tend to have more of the middle sized pores or capillary water. Soak clay soils have a large part which is unavailable water. So of course the depth of restriction plays a huge role in how much moisture you are soil will be able to hold and tie the crop through from one rainfall from a dry spell to the next rainfall.

Soil profile can also make a big difference. There are some soils in the southeast of the United States, they have a soil horizon letter A horizon and the B horizon or the subsoil which is clay and rich in the southern southeast US also has subsoil spirit some of these have a he horizon which is not as rich and biological activity as the topsoil letter A horizon and is also not very rich and clay but it is impacted and it is hard for plant roots to get through. There are soils out in California an example is there is soil the Chualar loamy sand in Salina's Valley California and they have a dense clay layer at the B horizon. It is the Mollisol in a lot of the clay has moved down to the subsoil. The trick with the soils, is the those layers allow moisture to go through and they can leach nutrients away. And unfortunately crop roots have issues getting to the nutrients. So during the winter season when moisture levels are higher throughout the soil profile, a cover crop with vigorous deep roots such as winter rye or tillage radish, or sweet clover, mustards, can get through that compacted restrictive layer creating new route channels so the next crop can follow the route channel of the cover crop and get into the deeper profile.

Additionally, the deep-rooted cover crop will recover nutrients and I will play a vital role in quality and production.

So let's move onto dynamic soil properties and I want to add that that is an interesting about the last slide, so the somewhat restrictive layer and those particular soil types, although it is an inherent property that good management specifically deep-rooted cover crops can overcome that constraint and therefore through a dynamic property, improve the soil water relationship.

The way that any micromanagement influence of soil properties greatly affects soil moisture relations is through the activity of the soils, the microbes, the soil microbiota digest all of the input from the fertilizer, etc. Two active organic matter that is processed and as they turn this over that they create and maintain soil structure and that is soil structure is all about maintaining those capillary pours for every

one percent increase in organic matter that is measured in the soil test lab includes both the active instable fractions. On average, that will increase by 4%, the volume of soil that consists of the available water holding capacity. A huge role. When you improve the soil or getting matter, of the soil with a unsustainable cropping, you can double in some cases the available water holding capacity.

Maintaining the new route is vital, organic amendments can play an important role with those living cover crops. All crops that are grown. Also reducing all forms of soil disturbance, tillage, traffic, heavy use of fertilizer, and pesticides. That are applied directly to the soil is important.

In a healthy, biologically active soil, water relations look a lot like this as the rain seeps in, to the soil, the high water holding capacity retains a lot of it. And because it is a deep, open profile they plant roots can later access it in the amount of leaching that occurs as minimal unless we have a truly extreme weather event. You will see the capacity is substantial. To remember, you will see the yellow squiggles on the top, that is my attempt to emphasize that it is important to have the soil covered. If the soil is exposed, no matter how healthy it is, the direct rainfall will impact and then followed by hot sun will create some surface crusting, surface ceiling and reduced infiltration. And more runoff. So keeping the soil covered is vital. For that aspect of soil, water properties.

This is a summation of the ways that healthy soils will keep the crops better water. When the network of pores is open to the surface, the rain will soak in easily, and I had a positive demonstration of that locally. We had about a .5-inch monsoon over of a few days ago. And I was worried that there would be a muddy mess and seal over everything and I was surprised, because there was mulch on the soil, the soil surface was still open, and it was definitely moist, but it was good digging.

All of these, healthy soils, is well aggregated and has a low density in the biological activity continually recycles and maintains the pours. And then when the and tile soil profile is open to root growth, and you do not have a restrictive layer you get a great, maximum availability moisture.

What happens when the soil is compacted? If you have a subsurface issue such as a fragile pan or a cloud pan from just turning the soil to the same density year after year. Or you get surface cross because an adequate cover or inadequate roots, the rain comes in a lot of it runs off. Often the subsurface compacted layers will not be entirely watertight but they will block roots and you lose nitrate that way. An overall, the soil and poor condition is impacted.

In a depleted soil, and this can happen to some extent because the soil is very sandy. It is an inherent property. On the other hand, with an adequate organic matter when it returns the soil tends to be more depleted and not nearly as much available water holding capacity and profile because you do not have much biological activity. Re aggregating the soil in re-creating those desirable intermediate sized micro pours. And you'll get a lot of nutrient leaching in the situation.

So please remember, the available water holding capacity multiplied by the available depth that is available to the root will determine the total water holding capacity.

This is an example of good soil management, and its impact on resilience to weather extremes are on the left-hand side, is the Rodale long-term farming systems experience experiment and on the left hand is the organic system, one that relied on the lagoon covers for the majority of the nitrogen, in the other one that used animal manure. It had a complex rotation and was providing organic sources of nutrients are on the right-hand side was conventional, Best management practices. And in normal or wet years the

yields were for similar. But in a drought year there was losses in the range of 20 percent. That happened about three different years when they had a drought in that particular project. Or that particular site.

On the right, is the Walnut Orchard and Central California, this is after a two-inch rain, this is a heavy rain by their standards but that is not record-breaking. I was there 30 years ago, and we had a two-inch rain about twice a year. When they cover crop torture, low and behold, the soil is a little muddy, but it is not completely waterlogged whereas the orchard with the soil cap to bear, or herbicide, but that became a lake.

You will see a much greater decoration of soil health and much greater loss of nutrients and leaching in the bear soil situation.

So, as we talked about soil health and water holding capacity, we have a monkeywrench in the century and it is called, " CClimate change." The droughts are getting more extreme. And the extreme droughts, there is nothing living in the soil. The soil life is starving. This is getting more severe in the western part of the country. The most severely impacted with climate change and the Western region. That is with drought and heat. And then reduce our putting more restrictions on irrigating water that is available. The right-hand side we see a soil that was not prepared for the heavy rains that the eastern half of the country has always had an they are now getting more intense and of the risk of erosion is getting more severe.

We have this flash drought and it rains too much in the plants are not getting roots because there is so much moisture in the root health is not ideal in all the sudden it stops and goes up into the 90s day after day and the crops are not resilient because they have not formed deep healthy root systems.

Right now we have a mixed lesson, the snowcapped, 50 feet of snow melting out of Sierra Nevada and it's good news because the Colorado river is flowing like it has never had in a few decades. But the question is can the land absorb it? There will be flood problems as we all have heard. And we cannot count on that to continue, the drought is not over. We had one really wet year.

The Pennsylvania's Association for sustainable agriculture now called sustainable farming. They have been conducting a soil health benchmark study for more than 100 forms and looking at various soil health indicators including soil aggregation and moisture holding capacity. Year after year. In 2018, the eastern seaboard including Pennsylvania, had a phenomenally wet year, it was the wettest on record with a 50% more rain than normal. So the next time the farmers tested their aggregate stability it crashed. And when from the 70s down to the 20s. In both organic vegetables and in sustainably managed, low till, or no till, field crop rotations. The reason that the no till operations suffered the similar loss of stability, is that even though they were not tilling very much, they still had to drive on the fields, to spray, harvest, etc. To cultivate wheat, and that traffic was compacting the soil. So 2019 was normal rainfall, and with all of the forms and good management, either organic or conservation agriculture, they did recover a lot of the soil structure and interestingly, the pasture soil was much less affected. The fields that had the greatest year-round cover, the rotation was the tightest with the fewest days under bear fallow or barely established crops, those yields recover the quickest. The pasture soils didn't have a lot to begin with. One of the challenges that organic farmers face is without herbicides we have to control these things called weeds with cultivation. When you do several cultivation passes, the very surface becomes pulverized, and one heavy rain could cause it to seal over.

This is information from the National organic research agenda. It is the result of the organic farmer survey conducted by Organic Farming Research Foundation, and several water related production challenges are controlling weeds. Weeds are competing for water. And that came out by far the number one production challenge is weed management. Adapting to climate change was down on the list but it was more prominent and of respondents said they felt like this was a challenge. Drought management no surprise was increased in the western half. And then the use of variation especially in the Pacific Coast states, where the Mediterranean climate is raining and a lot of the summer when the rain is light in the temperature is more conducive to light season crops, that head a greater water usage. And here are some quotes from the focus groups. You see the link between water related climate change impacts and weeds. It gets difficult to cultivate for weeds when the weather is too wet. On the other hand if the weather is too dry the weed competition gets fierce. One farmer said they had resorted to using a lot more plastic culture, they had to heat the soil from getting supersaturated because they had brief, intense, downpours. So it would not wash the soil away and that so they adopted the system.

This is a study conducted by the Northeast climate hub. And I really have a lot of respect, I really like the way these regional climate hubs are working with farmers to help meet challenges of climate change into research the impacts of the problem. What was found is in the Northeast having both more frequent droughts in torrential rains that this was conducted during 2013 to 2016. More than two thirds of all crop insurance claims related to drought or too much rain. And after the 2016 drought that survey found that one third of the farmer said that they were responding by adapting improved soil health practices in building soil organic matter as even more it decided to install irrigation pick the next year it rained too much and 70% of the respondents said that they felt the soil health practices they had implemented to meet the weather extremes and droughts helped with the flood.

Here is an example from literally my backyard. This is 1 quarter/4-mile from my backyard where I live in a small community and we share garden. It is right by the river, beautifully trained soil, and we have this West Fork river, and in September of 2015, we had 20 inches of rain during the month. Seven of them fell on the 29th, in the river was running three feet deep through the garden. It pushed the fence over, and because my community mates had been extremely on the ball about having cover crops, we had four feet of sorghum Sudan grass to cover crop. The water pushed it down but did not take any soil, if we had just walked away after digging the potatoes, there would've been an alley several feet deep right? Were you see that cover crop. In a bounce back in kept growing.

USDA funded organic research itself is being hit with climate disruption and it is bringing or yielding not only great frustration but good lessons in resilience. One out of six USDA organic research projects funded between 2015 in 2021 have reported in the inner reports adverse impacts of extreme weather events. In some cases, the tornado destroyed some of the infrastructure or to cut a field, but more often it was severe drought, or severe Access rainfall that disrupted experience, reduce yields, forced to change the rotations, etc. " the ongoing 1000-year drought affected the Northwest region." There ours some great work going on to finish crop rotations in another one down in Texas with severe drought, it hampered the study sites. One of the sites at Lubbock was a complete failure. And the other site they all had to replant all the crops because of the weed pressure. Remember I mentioned that when there is drought pressure gets worse. And it is direct competition for the water.

In Utah, they found that if you apply wants just one time heavy application, about 20 to 25 times per acre of finished high quality manure compost, what happens is that it increases plant growth and

doubles wheat yields, and because you have more vigorous cereal plant growth you improve soil organic matter throughout the soil profile all the way down to 90 cm which is 35 inches.

So that was interesting, even though there was crop failure, the high rate compost gave them the best yield. Almost double. In the Texas experiment where ever they diversified the rotation, like cotton, or rye, they diversified it with other crops, this soils available water holding capacity improved. In the drought.

Let's talk more about how organic farmers with water quality and quantity. On the farm. Going back to the survey, one of the questions was about adoption of water conservation practices, such as drip irrigation, drought resistant crops, or scheduling deficit irrigation, to not use more than you need. Nationwide about half of the respondents in the west of course and no doubt in the South where we have flash droughts that went up to two thirds. Much less in the corn belt and you wonder why? Well, the climate change is manifesting as more rainfall, not to much is drought. Although 2012 was an exception. The Great Lakes and the Northeast and specialty crop farmers, especially are paying a lot of attention to the water conservation. Many of the organic farmers report the use of practices that could protect and improve water quality, cover cropping, trees, excess nutrients, crop rotation, when they are well-designed you reduce nutrient input in therefore nutrient leaching. And conservation buffer plantings. They could be extremely effective in intercepting nutrients that are starting to leave the field.

Looking at the four NRCS soil health principles, and how they directly relate to water quality and quantity. And what organic farmers do to address these. So keep the soil covered, as we discussed keep it keeps the creting and allows the water to infiltrate. A lot of organic farmers use mulching of various kinds. Especially organic mulch is good because they let the moisture in but they break the force of the rain. Cover cropping of course in the tight crop rotations just don't leave this will bear. More and more organic farmers talk about footing beds, that means we will harvest all of this in the bed because it is Mark ready and by then of the day we will have the next crop seated or transferred. Or there will be a cover crop in there.

Often they have shallow tillage if necessary to incorporate those two knockout weeds. Maintain the living roots that that has got to be the king of soil health principle. That is what builds the soil life, building the organic matter that no till which is exceedingly important for moisture infiltration, and it is the living roots that the old stable organic matter all the way down. Deep-rooted cover crops that relay planting, rotating the crops with perennial sod that gives you an entire 1 or 3 years. With continuous living roots. Living mulch has shown incredible capacity to improve water infiltration and basically stop the runoff. Of course you have the trade-off of the living mulch too close to your crop itself will can heat directly for moisture. In agroforestry practices are excellent for things like alley cropping in their excellent for increasing water retention in the system. And nutrient retention.

To maximize diversity you utilize soil moisture efficiently to support soil microbial diversity and function. It enhances the functions of the soil micro biome which includes regenerating and maintaining the soil structure and the water holding poor space. And the crop rotation that enter cropping, deep and shallow rooted crops, crop livestock integration, a lot of midsize organic farms, will integrate crops and livestock.

Minimizing disturbance that the less you till the better. It also minimizing chemical disturbance and protect the soil life. And the organic, well-managed organic system is strong to minimize the forms of disturbance.

So now cover crops this is a challenge and lower rainfall areas and will get into a more detail as we move on, but they do improve soil water holding capacity, all of these multiple ways. They prevent runoff erosion, and if the wind is strong it could flatten the cover crop. But you will not lose soil and you will not lose water to runoff. The cover that can feed the soil which will increase water capacity and the cover crop itself creates root channels and maintains an open portion sure. When the cover crop root dies it is an avenue for moisture to soak in. It is an avenue for the cash crop to send its roots after the moisture when it shuts off dry. You get a flash drought and you've soil with good health and your production crop will hang in there and do well.

The cover crop area you have the right component, and this euro grant component will absorb excess nutrients. And again it can penetrate subsurface hardpan's both in tillage pans and can penetrate some kind of inherent soil restrictive layers as I discussed. It will not break through the back fragile pan system. But the winter cover crop could get right through that. There is the one caveat to cover crop is using a lot of soil moisture. If you had a wet winter and you had 20 inches of snow melt into the ground that you had 4, 5, 6 inches of rain per month you will be happy to get the access out of there.

Here is an example from the southeast, South Carolina coastal plain, the soil with the letter E horizon. The only way that it can grow decent cotton is to subsoil, to cover the crop. Pretty strong physical disturbance for the soil. But what the study found is if you simply add a rye cover crop we are not adding a lagoon or a high diversity cocktail just right. That will increase the soil organic matter by .5 percent and that is a big increase in increase water capacity by at least an inch. And greatly improve the that access to the subsoil moisture. So the no till cotton yields went up 38%.

Organic mulches are excellent and they are like a heavy valve. They break the force of the rain in the soil remains open, the water soaks in. When the sun comes out the straw layer will slow the evaporation. The wheat is in the second picture because it is also porous but if it rains hard, some of that will runoff. The plastic film mulch is used widely by both organic and nonorganic specialty crop producers. However, because it is more impermeable you need a drip. Patient system underneath it. And then when a rain does come along, all of the runoff that the picture on the right, all of the water and soil, and nutrients is leaving the field. In the excess water that that was only after a .4-inch rainfall. We do not even call that a big rain here in Virginia and I don't think they do in central California either and yet there it is. That is a drawback in a concern with those nonporous plastic mulch systems.

Organic amendments, compost, manure, biochar, et cetera the good news is that these organic amendments work in a synergy way with living cover, highly diverse rotation and high year-round cover crops to build all aspects of soils including the available water holding capacity. And since compost is essentially 25 to 50% basically active and stable soil organic matter it is directly contributing water holding capacity in that way as well.

The soil organic matter pulling impacts through finish compost is the best. It is better than a similar amount of Solomon newer and better which in turn is better than poultry litter which is concentrated. And manure slurry and anaerobic digest date they do not build soil organic matter better than synthetic soluble fertilizer, so really you want to look to the finish compost or at least a solid managed newer resources.

Biochar has a very interesting properties, and when used in conjunction with other practices that they build your water holding capacity in your permeability. Resulting in more research is needed with that

biochar. More is not always better because if you overdo manure compost U-boat build excess phosphorus and you may have access mineralized will nitrate which reduces water quality. In the high phosphorus will shut down the fungi which is reduced with crops with low to moderate or low in optimum phosphorus. The plants will partner with the fungi which will play a vital role to maintain that physical structure.

Reducing tillage, organic systems cannot go continuous no till because they do not have herbicides that we can resort to to manage weeds without any tillage. However there are many practices that have been practical in organic farms and will discuss more depth in the next webinar. I will happen next month. On organic tillage practices. Basically any of these efforts to reduce tillage either strip tilling like you see here or ridge tillage. Any amount of strip tillage in the western United States, a sweet plow undercover known as a noble late plow, sever suites in cover crops just below the soil service in most of the residue is on the surface. Which reduces wind erosion and conserves moisture.

The shallow and non- inversion tillage practices like a speed disc, or a rotary harrow or a Rototiller if it is not grown run too often or at two high-speed, that could support higher microbial biomass in turn plowing or other tilling. We are making sure that there is plenty of nutrients going back into the plant.

For cultivation, it is great for knocking out weeds, if you have the time Dragon you go shallow, you do have the risk of stealing the service as you see on this example on the right. So the trick is to use organic weed IPM to get a strategic crop rotation, cover cropping, to reduce weed growth, prevent seed set, mulching, mowing, grazing, flame weeding that will reduce the number of times you have to cultivate each year.

Rotational grazing systems if properly adapted to the region, and this means fearing the rest periods and the stocking rates, and the grazing time which can range from 12 hours to 3 or 4 days. In the most intensively managed rotational grazing. When it is done or the timing is correct, you will get an increase in the soil organic matter in the cover or the permanent cover will maintain the water holding capacity of the soil. It yields high-quality forage in next the system more drought resilience. Very often if it is manage, you could be holding soil organic matter of one ton per acre per year and that is soil carbon.

So that reaches a saturation point with the soil is at optimum health and you have the question with more carbon after that but you have a healthy system that can absorb the heavy rainfall and keep things going through the drought.

The USDA National organic standards have a lot to say about water quality in various parts of the standard. Organic farms must protect water quality and protect the water quality on their own farm from accidental exposure, or runoffs, that would divert the water out of the organic field for example. Other examples are perennial buffers like trees, shrubs, etc.

Since the organic systems rely on plant and animal systems or were lessers, they have to be handled in such way to protect the water as well as the soil in the crops itself for access plant nutrients. Pathogenic organisms like in manure, and other unwanted subs this. Pastures which are required or the organic ruminants I would say musket 30 percent of the dry matter intake from the pasture during the grazing season, many organic farmers go well beyond that, 50%, 75%, 100% grass fed. That has to be managed in a way that the water quality is not at risk.

Of course production affects water quality, nutrients, pathogens, sediment, water quality could impact soil in the crops. If you have groundwater resources that are heavy in sodium or calcium or alkaline or saline. You have to be careful that that does not build up in the soil. And then of course the pathogen contaminants such as inadvertent exposure to a prohibited substance. The healthy soil that will protect the water quality by retaining or reducing the amount of water that is out in the field and therefore the amount of nutrients.

So there are warty quality concerns in different rainfall regimes. Here in my home county it is 45 inches per year. In Floyd County Virginia. There is a lot of downward moving moisture over the year. Overuse of nutrients from any source organic or soluble, will affect the groundwater. We are kind of at the high point. We are on the mountain in the county, so we have a responsibility to our neighboring county not to pollute their groundwater. So I do not load manure very sick on my garden and that is a reason why.

In a Mediterranean climate there is an intensive specialty crop producing region, it does not rain much in the summer so they have to your gait. But it does rain almost 20 inches a year but it's all in the winter. And they do not tend to have crop production in the winter it's just very heavy rains. It's not enough light to get good crop growth so they are often fallow. During the fallow is tremendous loss.

Then you get into the dryland, in the northern Great Plains, or the Mountain West, etc. The evaporation year-round is greatly exceeding the rainfall. So you have to net at work movement to bring soluble salts towards the soil surface.

So we will look at some of the challenges around water management. This is the big one, dryland wheat production is very commonly a week follow rotation. If you are conventional you will try to save the soil by using herbicide rather than tilling every six weeks. To keep the soil bare for the fallow. Even an endnote till system that the week follow rotation has been stress shown to reduce quality and the water capacity drops in the fertility drops and wind erosion increases. So what do I say? Plant cover crops! Yes it's a good idea except they will compete for the limited soil moisture and the crops are already up against the weeds. There are stubborn weed problems like that are out real nightmare. If the timing is not right or you do not have a good cover crop that the weeds could grow up with the cover crop, and anyway. I am not saying do not cover crop but good news there is some cover crops that combine drought resilience, high biomass, and a fairly low demand on soil moisture. So if you time the planting correctly, you get a lot of it if it. And little to no yield cost.

So some examples are Pearl Millet which performs great in Virginia, it is very efficient with the water and it will not degrade your crop such as others. And surprisingly winter field shows promise as a winter cover crop in dryland rotation. It grows well in the cool season and uses a limited amount of moisture.

So I created this chart from a more extensive cover crop chart. An information bulletin at the USDA. All cover crops can be mapped on a scale of low to high drought resilience and low to high water usage. So things like Alpha Alpha, sunflower, safflower are known for drought resilience that they also use a lot of moisture. So if you do not want them in the rotation, for your dryland wheat crop, a lot of the cover crops that do well here in the deep South like the Gulf Coast, and the Carolinas, and Florida, sung him Sudan grass uses a lot of moisture and they do not always perform in the dry climate of the Great Plains. Here is an interesting group, medic riches related to alfalfa. They do not have a huge biomass but there are very drought tolerant and fairly light in the water usage. Barley is the best cereal grain because the same set of properties. Also somewhat salt tolerant. Pearl and fox tail Millet's will come up and drop soil

like and I will plant fox tail Millet in the summer and a week later it has not rain, they are very impressive. Field PEA and mustard and southern PEA do well as well. We can pick cover crops for our location based on the chart.

Here are a few examples, and California Central Valley, all of the rains in the winter. It has an interesting trial, it was an NRCS trial, conducted in the Central Valley with various cover crops. On very limited moisture, things like vetch, field, bill being that need a lot of soil moisture that they did not do very well in the Central valley of California. They do well in the Pacific Northwest and are used for nitrogen in the winter. In 2013 that they preach here a gated two inches, planted the cover crops and then everything else was just natural rainfall. Like a six-inch total rainfall in February and March. Surprisingly the Cucamonga California brome and the [white mustard exceeded five tons per acre of biomass. That is higher biomass then the triticale that that was four times per acre which is still excellent but it saved the most soil moisture. It did not soak up as much moisture there was more left for the crop in the spring.

In the northern Great Plains, it is a different situation that the rainfall is distributed more around year and you get thunderstorms in the summer, some snow in the winter, etc. There was a Western survey and 30 percent of farmers were using cover crops because they knew about the soil health benefits. They did find that in some cases the water in the nitrogen used by cover crops can actually reduce wheat yields and when the difficult trade-offs are there. One crop that has done very well is black lentil. It is a cash crop. It is good rotation crop. So Doug Crabtree and Anna Jones and Crabtree have on their farm in North Central Montana. They grow 15 specialty crops, and ten cover crops and they have an amazing system. They have been hit by severe extremes of weather related climate change. They still managed to produce good enough yields to stay in business. The soil health is improving steadily.

In these regions, what has been found is that if you plant the cover crop from the fall or early spring and you terminate when that first comes the flower. Do not wait to plant the cover crop because you do not want to deplete the soil moisture. So if you have a water hog like alfalfa produce a lot of biomass but no moisture for the week.

In Northeast Washington, we go back to more Mediterranean patterns where almost all the moisture all 11 inches of it comes in as winter snow. They do not get the nice soaking thundershowers in the soils are shallow in stony. The conservation innovation grant that determines what does the best? So field PEA terminated in the spring and about ten percent of bloom. They found that you have to plant these crops in the spring because in the fall it is to drive. You need to plant them when the snow melts and then you can get the cover crop benefit.

So my other favorites, the southern PEA and the sun hemp... others are not as efficient. It can be a big problem out in the western US. Wheat varies widely from the actual significant gain to a severe loss. The determining factor is whether the soil was dry to a depth of three inches or more. If you plan wheat at three inches and an moisture and turning the cover crop in such a time that it will leave the moisture which in the first few inches of the surface. Then the week yield is normal or increase because of the better soil health.

If it is to dry, which we do? This study by Jennifer Reese and colleagues at Utah State University found a one time application of good compost at 22 tons per acre, improves the aggregation, water filtration, enhanced root growth and soil matter and 35 inches. Greatly increased the wheat yields in the drought years. Those crops gave the best yield by far and they found they did the first experiment for 25 years in

those fields are still showing higher organic matter, higher phosphorus, phosphorus can be limited in those regions, and higher wheat yields than the fields next to those fields. The fields that did not receive the compost. The University of Arizona is doing an innovative study which is funded by the organic research in extension initiative and they are using composted grape palmist and manure. And believe it or not this incredibly valuable organic resource is currently being landfilled. Can you believe it? Here we are, alkaline soils, really acidic byproduct that is all organic and decomposable. It is very acidic. Like sulfur, using that to lower the pH. It is not just a mineral that may be upsetting to the soil life. They found that they are now experimenting with composting this acidic plant residue with manure to get a balanced compost. They will be watching what it does for the available water holding capacity. As well as other soil health indicators and the crop yields in the economic returns. I cannot wait to see the results! It can be a valuable repurchasing of inorganic byproduct that is currently being and could instead improve water relations in soil health. In aerated region agriculture.

Here is the blade plow, if it is to drive for year-round living cover that this is a handy tool that the challenge with it and I have learned this from Doug Crabtree in an interview. He is one of the best organic conservation farmers in the country. You have to have the soil just right just moderately dry, if it is really dry it will not penetrate or work right and if it is too wet, it will not sever the root grounds properly. If you get in there at the right time, you can terminate a cover, and knock out all the wheat that have come up with it. In one pass and there is 90 percent residue cover in the wake. So wind erosion is curved and soil moisture is retained.

Yes so here is another follow field down and central California. This is a two-inch rain that that is not the big flood we had in Virginia and that was nicely absorbed by our soils. Just a few inches, and the problem was most of the rain falls in the winter. So surprisingly the cover crops are rarely grown and I was wondering about this. So then I realized partly and I will show you. The ponding is not good for the soil, any moisture that runs off of course is not there for the next season. It also may cause erosion. The NRCS scientist in the central region of California

>> MARK SCHONBECK:if the broccoli harvest is done in September, the Berkeley residue itself may contain 150 pounds of nitrogen. The system they were providing slow release organic nitrogen in the form of compost. In November, the new manure compost may be chicken compost. You had a huge amount of natural nitrogen in the profile. In all the precipitation in the winter. Yes you planted the strawberries when you put the manure down but the strawberry growth through the winter months is so minimal it is not using the nitrogen all the nitrogen leaches out for the strawberry hit its pace and has a big demand for nitrogen.

So this is going back to the lettuce broccoli system. They all had the same result the nitrogen left over from the Berkeley was already covered, and just having the cover crop breaking down and having it killed in an decomposing supported the high-yield's consistent good lettuce crop around 30,000 pounds or an acre.

You have a transition from really dry summers, no rainfall, and then you going to potentially white heavy rainfall in the winter. Between September or late December. If you have the last irrigation in late August, and then you harvest in the middle of September, you have a certain range of soil moisture where you could get to plant a cover crop. If it is too dry it will not germinate, if it is too wet, you will drive into the soils and sink right in. In damage the soil and you cannot get the job done. In a wet year, the red line is early onset rain and I think I have these backwards so the crop is drawing down the moisture. Let's say

you have three inches of rain overnight and it's already too wet laid the cover crop. Or if the rain set in late we go to Christmas time, and you wait for the cover crop and it gets drier, and drier, and drier. And you may have given up at that point and I understand the challenge.

So one idea may be to plant the cover crop while the production crop is growing. We get started, in a way that will not compete with the cash crop that it is still going to be providing a cover once the cash crop is finished. The lower left an example is a plastic mulch system where you have the runoff in the alley but if you put a with thick cover crop and in the upper left is winter seated clover. On the upper right-hand side is an experiment with Oregon State University, the upper right-hand corner is the eggplant harvest is complete in the plants were killed by frost. In the over seated oats are preventing runoff and leaching in building organic matter. The lower right is a winter squash crop maturing in the sun. The crops have died from a light frost. In the red clover that was over seeded is now covering the ground.

Which is more efficient? Drip irrigation is much more efficient to get moisture to the crop than overhead sprinkler that there is a drawback. In a dry climate, when you hear gate just where the crop is, all of the soil stays dry week after week, and the biological activity goes dormant and there is no more nitrogen mineralization from the organic matter. So no matter how good the cover crop is, you will not have enough nitrogen to support the crop. You may need to up the row fertilization. In arid Regions you depend on groundwater resources for sodium, calcium, or general alkalinity or total salinity. So you can get the soil conditions in a dry climate. It degrades soil health in the irrigation does emphasize and it is tricky because you can turn the soils and to prepare for farming. That is something to look at closely. In the example of creating an acidic compost to counteract the suit the alkalinity and build up the soil biological activity, may be a part of the answer.

Organic orchards that these are irrigated orchards, and a lot of orchards at least in the past have said, “wWe do not want anything competing with the trees.” But keeping the aisles covered in a good cover crop, and even planting right under the trees, low growing, low moisture demanding plan such as the mustard family, and improves root growth in improves soil organic matter, and water holding capacity. In fact, several studies have shown that bare soil can cut soil organic matter by half compared to keeping a decent cover crop there. So it does not compete with the trees for nutrients or pollinators. These systems not only meet or improve tree growth. But the water needs are unaffected. So you are able to build up the soil and improve the tree health growth.

One last research trial, the drought has really put the squeeze on California tomato growers. This year may be an exception with the snow melting, but we cannot count on that every year. Farmers have been encouraged to try something called deficit irrigation. Instead of cutting off the irrigation on the tomato pump before her 30 days they went to 45 days. Some researchers at UC Davis led by Dr. Gauguin and midscale organic stubble producer by the name of Scott Park, Scott Park organics, did this experiment where you try cutting off irrigation early two years of experience comparing conventional and organic fields. To compare the standard irrigation schedule and cutting it off early. The park farming organic rotation is very diverse and includes winter cover crops which as I said is not widely used in this area yet. It uses compost and microbial inoculents and reduce till. The outcome is of course you retain the rainfall and the first year we try the deficit irrigation. He saved about one half an acre foot. No change in yield or no yield sacrifice at all. The second year was even more interesting. On the left-hand side you see the yields was standard deficits and the yields are the numbers inside the bars, the bars themselves

to shows that efficiency. Like the yield per unit moisture. You may have a slight change in yield but not much at all. It turns out that you do not say that much in terms of water use per ton of tomatoes. In organic systems, even on the standard irrigation schedule they needed much less irrigation of water per acre to sustain this same yields of 40 tons per acre. Of course the deficit irrigation cutting off two weeks early even further increase the water efficiency. There was some improvement in the quality or desirable secondary plant products and a few were rotten fruit in the field. The fruit was more robust. I was not there for the taste test but I imagine it tasted better too.

Okay I think that is it! Questions?

>> MARY HATHAWAY: Thank you so much. We do have a number of questions. I will start from the top.

Could you further discuss approximately how much water holding capacity or infiltration rates change with one percent of soil organic matter? How much more water could the soil infiltrate and hold per acre?

>> MARK SCHONBECK: The infiltration will depend to a fair amount on the structure of the soil and especially the surface course amount in the water holding capacity. I am taking this from a study cited in the nature and properties of soils, the 15th edition published in 2017, from the graphs show that this is based on studies on several soil types in the Midwest, but for each increase, if the 2% organic matter to 3% organic matter, you will add about 4% by volume in available water holding capacity. So if you have nice deep-rooted crops, 4% of 30 would be 1.2 inches of moisture additional held in the soil. That is just a rough idea but it is very substantial.

>> MARY HATHAWAY: Oh that is awesome. Another question, this is a contentious one, I hear a lot referred to regenerative practices is one of theory other than another? My experience is that or regenerative is a part of organic and not of the other what are your thoughts?

>> MARK SCHONBECK: Regenerative can be contentious is that it does not have a legal definition. The way organic does. When I say regenerative I include only organic agriculture that is done well. And also conservation agriculture that is done well. Conservation agriculture can include some chemicals. If we talk about a system that uses or meets all of the four principles of soil health, keeping the soil covered year-round, growing most of the nitrogen or legume and legume grass cover crops, using organic amendments. Reducing tillage and minimizing chemical inputs and if they say okay we are not organic we can put 30 pounds of nitrogen on. If things get out of hand we can use herbicides once a year, I would be open to considering that regenerative. In organic agriculture when it is done well or done to the spirit and letter of the organic standards then yes it is indeed regenerative. Tons of studies have shown an upward trend in active ins total soil organic carbon. Soil biological activity, microbial biomass, in this definitely includes organic systems. If the use tillage or routine tillage if it is done carefully especially shallow non-inversion tillage practices. And they can sustain higher levels of soil biological activity and soil organic matter than a continuous note till system that relies heavily on the use of herbicides to control vegetation. If you heavily rely on chemicals the disturbance is severe as excessive killing.

There is a sad story of an organic farm that was started on a very large scale and they did not pay attention to the constraints of the soil and the climate working with. They ended up over tilling and having severe wind erosion. I would say that organic is a very important component of regenerative and

it is a less well defined term and it is easy to be misused. A could be applied to any no till system regardless of the chemical input. It could be applied to the systems that meet organic not the spirit because they are not tending to soil health. They do exist. I would also say that on the whole, most organic farmers are committed to making their system as regenerative as practical. For every bad example I run across 30 very stellar examples.

>> MARY HATHAWAY: Thank you that was very helpful and thoughtful answer on that difficult question. Another question, to clarify a little more about organic no till, looking at Indiana and some of the work at the University of Swanson in how folks are mitigating this because of herbicide resistant weeds? If you have any comments he also provided some videos as well in the chat.

>> MARK SCHONBECK: Yes continuous till can be challenging. The big challenges weeds and cooler soil with lower mineralization and the upper half of the country and also delayed nitrogen mineralization and dryer comments and especially Mediterranean climates. There has been exciting advances in Cornell working with incredibly innovative organic farmers. They have 1900 acres of organic range and they have developed an extended no till sequence where they can do a winter cover crop and grow soybeans and follow that with another cover crop without tillage. So they have been careful with strategic management to plant several relay planting one example is they had a forage crop sorghum Sudan grass, and harvested the forage. They planted the rye and Moss treat piece into the stubble in that actually work better planting in a tilt field because it created a favorable microclimate for the fall cover crop to establish. In the first frost knocked out the sorghum Sudan stubble before it could grow back to compete severely. There is very exciting progress going on. I know that Aaron has done excellent work in the field. I am just watching the results in eagerly awaiting for the next findings.

>> MARY HATHAWAY: Thank you so much for that. Another question refers to one of the University of Arizona trials. He asked could Apple squeezing from a cider press be used in the same manner as the great pumice?

>> MARK SCHONBECK: I imagine it can be to combine that with manure tends to be alkaline so I think it would be a very nice balance. If you just try to use the ascetic plant waste by itself, it could unbalance the soil. But if you combine those together you will get the mix. You will get a microbial feeding frenzy which is what you want.

>> MARY HATHAWAY: Thank you and we have another question can any of the speed frost seated and will be successful? I think this was on cover crops when it is to drive for year-round cover?

>> MARK SCHONBECK: That is interesting frost seeding of clovers has been excessively successful. So we did seat a bunch of clover and then snow came that night and we could've laughed and then we had the best clover understory that that pastor has ever seen! It was great. I do not know how well it would work in the cold, dry climate. It may be a superb breakthrough or it may be that the subtleties of the climate, just like I thought that nothing could be Southern PEA and Pearl millets for drought resistant covers. But they do not work in the southern Great Plains because nights are too cool. I think you have to go out and try it. You could even go out and snow seed it or plant before the last snowfall. That it is worth trying. Anything that will not take too much moisture I would say go for it.

>> MARY HATHAWAY: Thank you. Just a note, during the soil health training in Pennsylvania we have always said that 1% increase and soil matter equals 25,000 gallons of water holding capacity so like we

say it is very relative to water property. Another question came in, I am surprised that there was no mention of the importance of using goats or sheep for controlling the organic or regenerative systems. They can be very good at controlling weeds.

>> MARK SCHONBECK: Yes great. Where I missed that one was in the weed webinar. I know that there have been some experiments out West and in Montana trying to integrate grazing to terminate cover crop and control weeds. So yes, I would say that is another really good avenue to explore. Thank you.

>> MARY HATHAWAY: We have another question how would you like to see soil health management be factored into the watershed management to catch more water and address multiple needs?

>> MARK SCHONBECK: Yes watershed management. I think the entire watershed, the first thing, is one of the Virginia Senators top priorities which I'm very grateful for. So for agroforestry, getting trees back on land, if we are talking watershed level management, we have to think watershed level landscape management. It will not happen in an individual cornfield. I would like to see every single stream as big or bigger than the Little River, that I showed you that was flooding be put into the right buffers and that would be a huge step towards water management and water quality. Within the farming ecosystem, if you are on the slope, there is a farm here in central Virginia and it is organic, it is forming on a hillside, ten percent slope. Growing vegetables. Using the soil will wash away? But he worked with NRCS to set up a series of terraces, the terraces are covered in agroforestry planting so multifunctional and harvestable crops. Some are windbreaks. Some are the just there to hold the soil and retain moisture. Inside each terrace is 8 or 10 beds that are entry-level and placed on the contour in the rotation of annual cover crops. I think that all of the moisture is retained on that land. Farmers have been doing things like this in China in the hilly parts of China and Southeast Asia for 4000 years. Still productive because they have kept the soil in water on the land.

>> MARY HATHAWAY: That is so great Mark. We have one more question. I know we are almost that time. But you mentioned that excess potassium inhibits fungi which they reduce drought resilience, are there other examples of nutrient excesses or microbial interactions that can directly or indirectly impact water uptake?

>> MARK SCHONBECK: It was phosphorus that was most directly impacted by fungi, the potassium axis would be a problem if it got extreme or out of balance. So it is really phosphorus. And also if the soil is very rich and plant available nitrogen regime if it has inputs like composting manure or standard synthetic fertilizer or manure slurry. Any of those ways, sources of excess nitrogen will tend to inhibit the most beneficial organisms including fungi. I do not know of any other specific ones. For instance, if your nitrogen is abundant, you will not get as many nitrogen microorganisms and either legume or non-legume crops. Which ones will indirectly affect for water capacity? I would only speak to that in general terms and that anything that reduces microbial activity and biodiversity is going to tend to reduce the process of continually maintaining that space. And if you have those levels crops may not have the extensive root level they do not have to go as far to get what they need.

>> MARY HATHAWAY: Thank you and I had one last question. Can soil compaction lead to decreased water intake to water aquifers in if so should these be prioritized?

>> MARK SCHONBECK: Absolutely if the soil is compact, and it is running off, or going into the soil, it will not get to the groundwater. I have read that there was a study in Texas, as part of the country were

aquifers are to being depleted at alarming rates. And there's a study of rotational grazing with those practices by improving soil moisture and absorption reversed the trend towards declining soil water. So if the water table is rising and that was exciting. I would say yes if you do anything to reduce capacity, cover crops, maintain root biomass, etc. You manage the nutrient input and provide organic input. Anything that will improve the uptake capacity of the soil or meeting service residue and up till management all of that is going to bring more water back to the groundwater, the aquifer, and have less runoff into the river or into the road.

>> MARY HATHAWAY: Thank you so much Mark. With that we appreciate your time in the presentation. We appreciate your thorough and thoughtful answers. I will hand this over to Jennifer.

>> JENNIFER RYAN: Thank you. On behalf of the USDA and the natural resources conservation service is, we wanted to say thank you to Mark and Mary for providing an excellent presentation today on organic soil and health practices from water management and water quality. Thank you again to everyone for attending today's webinar. Adjustments do not forget to provide your feedback about the webinar and if you select to earn CEU, please return to your open browser window to continue to process offered by step to add conservation webinar.net. This concludes the webinar presentation. Thank you everyone!

>> MARK SCHONBECK: Thank you!

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