University of Minnesota Nutrient Management Podcast Episode “Soil fertility: fact or fiction?”

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Maggie Frazier: Welcome back to University of Minnesota Extension's Nutrient Management Podcast. I'm your guest host Maggie Frazier, Communications Specialist here at UofM Extension. Today on the podcast, we're talking about soil fertility, fact or fiction. We have three members of extension's Nutrient Management Team, Fabian Fernandez, Dan Kaiser and Carl Rosen, to cover the basics and beyond.

Maggie Frazier: Welcome, how about you each give a brief introduction of yourselves?

Dan Kaiser: This is Dan Kaiser, I'm a nutrient management specialist here in the Department of Soil, Water and Climate. I'm also with the University of Minnesota Extension.

Carl Rosen: Hi, this is Carl Rosen. I'm also with the Department of Soil, Water and Climate and nutrient management specialist. I work a lot on irrigated systems, but also do quite a bit specialty crops, some of the processing crops on dry land soils as well.

Fabian Fernandez: I am Fabian Fernandez, also a nutrient management specialist here in the Department of Soil, Water and Climate. My area of expertise is in nitrogen management for corn cropping systems and water quality.

Maggie Frazier: All right, let's jump in. Fact or fiction? Plants prefer organic sources of nutrients because they're more available.

Fabian Fernandez: Well, that is actually fiction. In reality, organic molecules have to be changed to inorganic forms before the plants can use the nutrients. Plants don't take organic nutrients, they have to become inorganic molecules before they can be used by the crop. And so, that's a misconception. I think it maybe comes from the fact that a lot of people talk about organic agriculture and things like that, but the reality is that plants will not take organic molecules as nutrients.

Carl Rosen: Right, and when you apply an organic fertilizer, it has to be broken down before it can be taken up as Fabian said, in the most simplest forms, the ionic form. This isn't to say that there aren't benefits to organic fertilizer, organic nutrients sources, manure for example helps improve soil quality in many different ways, because of the carbon in there, and those things that help soil health for example.

Carl Rosen: But in terms of a nutrient source, they need to be broken down into the ionic form in order to be taken up by the plants.

Dan Kaiser: Yeah, this argument usually I see come across between organic groups and conventional ag groups. And what Fabian and Carl said, is both true. The main challenge I always see with organic sources, while they can be readily available, is always predicting that availability. So you see that a lot, we're seeing people, especially homeowners here in town in town in Menards, and picking out things, a lot of them are really erring towards some of the organic sources. And really the main issue there is, we just don't know the availability on some of these products.

Dan Kaiser: So we know that plants themselves really between the two, don't really favor the organic, meaning they're really looking for the inorganic source, and really with the organic sources, it really just boils down to availability. So, that's the main challenge with this one. It comes up a lot again, just in this argument versus why go organic. And really from that standpoint, there's nothing wrong with it, it's just with in terms of nutrient sources, we know that really the inorganic is what that crop is looking for.

Carl Rosen: Right. To follow up with what Dan said, the availability is really temperature dependent, particularly the carbon and nitrogen, the organic nitrogen sources, its microbial process to break it down, and so you need ambient temperatures as well as moisture there for that product to go through that cycling to the inorganic form.

Dan Kaiser: Again, it comes back to availability. And you look at a lot of these products, really the nutrient concentrations of them tend to be a lot lower. So that's one of the things when you look at total amounts required, you tend to see more of an organic source needed in most cases just because of all the extra stuff, the extra carbon and everything else that's accounted for in those materials.

Dan Kaiser: So, really in terms of the two, it's just easier managing with inorganic, just because higher concentrations and it's a lot easier predictable availability and come up with a fertilizer application rate.

Fabian Fernandez: In addition to that too, is in organic sources, they are not balanced, and so different sources have different concentrations of nutrients. As Dan mentioned, they typically are lower concentration but they're imbalanced. So for instance, typically with manure, if you're applying manure, you will be likely over-applying phosphorus and not applying enough nitrogen. So it's a lot easier to deal with those balances with an inorganic source that is just one nutrient, or it has a specific concentration of each nutrient that you can balance more easily.

Maggie Frazier: Fact or fiction? Micronutrients like sulfur are becoming more deficient with greater yielding crops.

Dan Kaiser: You know, I love this one, because this one comes up a lot. Lumping sulfur in with a micronutrient, and that's really the main fiction here. Because sulfur we know is a macronutrient and it's needed in large quantities. It comes up a lot when I'm on the road. People thinking of sulfur as a micronutrient. We can't really be looking at it, even though we've demonstrated you can do a lot, in terms of increasing yield with a low rate of sulfur. It still isn't a micronutrient, just because of the overall uptake.

Carl Rosen: That's right. And technically sulfur is considered a secondary macronutrient, the primary macronutrients are nitrogen, phosphorous and potassium. Secondary macronutrients are sulfur, calcium, magnesium. To kind of put it in perspective, if you look at uptake of a micronutrient, you're looking at maybe ounces of a micronutrient, something like zinc, or copper, ounces per acre in terms of actual uptake by the crop. Whereas, macronutrients tend to be taken up in the pounds per acre, so maybe 20, 30 pounds, 30 pounds of sulfur might be needed for a high yielding corn crop.

Dan Kaiser: And when we look at facts, we do know that uptake and removal are highly tied to yield. So there is some truth here in this question, when we start talking about increasing crop yields with increasing removal, the question, and as Carl mentioned, when we start talking about micronutrients, we typically measure the uptake analysis to the acre.

Dan Kaiser: So, say we increase crop yield by 30%, yes we'll increase removal probably by about the same amount, although I think as Fabian, before he came here to Minnesota, he was looking at this in Illinois. And we've also looked at here, in terms of some of the nutrient concentrations actually declining slightly, with some of these higher yielding crops. So it seems like we're breeding these crops to have a greater starch content, and you're really diluting down some of what's in there.

Dan Kaiser: So, we haven't seen really that great of an increase, although we do know that there's a direct tie in with removal, particular when we start talking about immobile nutrients phosphorus, potassium, most of our micronutrients. So, while they're becoming a greater demand, we haven't necessarily seen a great increase in the overall requirement, particularly for ... we'll talk about a micronutrient like zinc in corn production, because we know that there's a greater uptake, but the uptake isn't as much. And still, when we look at a lot of our data, it really doesn't take a whole lot in a deficient situation to increase yield.

Dan Kaiser: So like I said, this is kind of one where there's some truth, and there's some fact and fiction built in.

Fabian Fernandez: And just one more point of clarification Carl, you mentioned the macronutrients being primary or secondary micronutrients, and the distinction there really has not very much to do with how much the plant takes, it has to do more with how much of those nutrients we normally apply in agriculture. So, normally nitrogen, phosphorus and potassium are the primary, because those are the ones that we get the most response to, and we normally apply on a regular basis. Sulfur, calcium, magnesium, historically we don't really need to apply those nutrients, although sulfur is becoming more of a nutrient that we apply on a more regular basis. Depending on where you're from, you know, I grew up in Argentina. Argentina has a lot of sulfur deficiency, so that's kind of one of the macronutrients in there, just because they had to apply more than potassium for instance.

Fabian Fernandez: So that's the only distinction between primary versus secondary, but they're all macronutrients because as Carl mentioned, they are required by larger quantities by the plant.

Dan Kaiser: And when you look at our macronutrients too, the only one really right now that we aren't tying any of our recommendations to the yield is nitrogen. And if you look at the data, we have a substantial amount of data, when you look at the optimum nitrogen rate versus yield, that there hasn't really been a direct correlation. It's one thing I hear a lot right now.

Dan Kaiser: Particularly when we start talking about some of these things that have been coming out with the nitrogen rule, has been being able to maintain increased nitrogen applications with increases in yield, and we just aren't necessarily seeing that those two go together. The removal basis, particularly for P and K, phosphorus and potassium, we know that with increased removal, we can see increases in the decline over time if we don't apply fertilizer in those given fields.

Dan Kaiser: Although it is very slow, on average you're probably talking about a two part per million decrease for the Bray soil test over time without fertilizer application. If you're starting in, we'll say kind of a medium to high, you're not really in an excessively high situation with manure, which we know that decline is a lot quicker, and probably about four part per million or so with potassium. So those are kind of average. We would really expect those, just based on removal. And nitrogen's kind of that outlier at this time.

Maggie Frazier: All right. Fact or fiction. Variable rate application of fertilizer will increase crop yield.

Dan Kaiser: I mean it's an interesting question. I think on average I would say probably fiction, but it really depends on a lot of factors.

Fabian Fernandez: That's our favorite word in extension. It depends. Because it really does.

Carl Rosen: It could in some cases.

Dan Kaiser: I mean really, it's a question of how you're setting up the field with soil, through a soil sampling scheme. Because really with variable rate, what you're really looking at doing is trying to even out the field. So you're trying to look at putting fertilizer where it's needed, and then maybe cutting back where it's not needed. Because we look at in terms of trimming back fertilizer, you apply less fertilizer, you wouldn't expect to get greater yields. So really what you're again looking at is, identifying low areas that you may be under fertilizing, particularly with phosphorous and potassium, and then looking at those areas that are grossly over-fertilized, because really looking at in terms of variable rate, a lot of what you're looking at in terms of the benefit there, is cost savings and looking at trying to reduce the cost in the area, and trying to increase profitability. Because we know the low areas are out there, but being able to fully identify them, that boils really down to the soil sampling scheme.

Fabian Fernandez: Yeah, and the other important thing too with all of this, is there are two kind of views to these right. One is, you kind of even out the fertility across the landscape, so everything is uniform. The other one is to try to equalize the yields. And another one would be to improve the productivity or the returns, right. And those are two different things sometimes, because maybe an area where you get the highest yields and you apply a little bit more fertilizer, it can help increase that yield even more, maybe that's where you want to put that fertilizer, versus applying it an area that is not going to yield very much more.

Fabian Fernandez: So it's two different approaches right, to how you apply fertilizers. Whether you're trying to equalize the yield across the entire area so that the low yielding areas get higher yields, or if it's applying where you will get the most most profitability.

Carl Rosen: I guess if you're looking at your yield map, and you apply the fertilizer where you have your high yield based on the yield map, but then on the other hand you could be basing it on your soil test. So phosphorus far example, you put the phosphorus where it's needed on that low area versus the high area, then you don't put it there. Same thing with potassium and PH. You know, you put the ... Kinda even it out, based on that soil test. But you may not necessarily get higher yields in those areas.

Fabian Fernandez: And I think it also comes down to the approach that you're using and also understanding what's the level of confidence you have in the data that you're using to base that application, right. If you are basing it off of a grid sampling that's a very large grid simple, you know, the clarity that you get on that data is not very good, you know, if you're basing it out of, I don't know, a 10 acre grid simple or something like that, well if there's no variability within that 10 acre field, then you're probably not going to improve things very much.

Fabian Fernandez: Now if you to a grid that is maybe two or one acre or something like that, then okay, you maybe be able to start really getting closer to where you need to be looking at for management.

Dan Kaiser: Well, I think the main thing is, and I think I said this before, is how you assess that variability. Because we've got the capability to really look at fine tuning applications with the variable rate spreaders that are out there. Really the question is, that starting point. In soil sampling, how fine of a scale do you need to get to be able to really fine tune applications?

Fabian Fernandez: When we are talking about soil sampling, we are talking about PNK, we're not really talking about nitrogen.

Dan Kaiser: Yeah, nitrogen, I mean you could look at it. We do have recommendations in areas of the state for using two foot test. If you wanted to look at variable rate application, I think there's maybe some movement there that could be made. I think a lot of growers right now are looking organic matter maps, and probably assigning some sort of productivity values to try to look at fine tuning their nitrogen recommendations.

Dan Kaiser: We just haven't been able to completely identify through research that these are practices that are affective for nitrogen. P and K it's fairly easy, because if you look at how we have the guidelines, I mean really what we're looking at for most of our guidelines are probability functions.

Dan Kaiser: So looking at what probability based on your given soil tests are you going to see some sort of yield response, whether profitable or not, from a fertilizer application. And then the question is, can we get all these low testing areas. Because if you look at a lot of the data, you think of manure being a very variable application, where you get a lot of variability imposed in your field, with a manure application. The same thing can happen with the dry fertilizer applicator. If you're not looking at getting a real even spread out there, we see a lot of variability, and if you look at these fields, it's just imposed by our previous management.

Dan Kaiser: So, it's really a question of how to best address that. I think it'd drive you mad just trying to get to all the variability. You seem to come up with some sort of plan for a given field that works well to at least to get most of the variability. And really where I look at it, is to try to get to those low areas, because those are really the areas that if you look at profitability, is going to be high where you can at least double your fertilizer investment in those areas. Then outside of those areas, then if you're getting an area that's pretty consistently in the high range, then you probably don't have to look at managing it down to a very small scale, because overall the probability of a yield response is gonna be low.

Dan Kaiser: So it's not a one size fits all strategy, but it's really looking at, in terms of how do we view these things paying for themselves, and not necessarily viewing it as that we automatically, that this technology is going to give us a yield increase, because that's really not likely what's going to happen. We're looking at trying to better handle that variability within the field.

Carl Rosen: And be more efficient with fertilizers as well.

Dan Kaiser: Corn and soy beans is simple. I don't know if [inaudible 00:16:42] crops, if it's as ... that or potatoes. I mean the different animals in terms of what happens, with fertilizer and how they respond.

Carl Rosen: To some degree, but I think P and K are probably ... we still have the same probability functions, and PH, lime applications would be very similar as well.

Maggie Frazier: All right, fact or fiction. Anhydrous ammonia is bad for some microbes, destroys organic matter and makes soils hard.

Fabian Fernandez: That's one of those that keeps coming up all the time. The most difficult thing sometimes is, when they're kind of half true. There is some truth to some of these things, but they don't necessarily completely apply. So let's start with the soil microbes. So anhydrous ammonia, it does kill the microbes, where in the retention zone of that ammonia band, so when you knife in anhydrous ammonia. First of all, it freezes everything that is in there, because it gets really cold right at the injection point. The other thing it changes the pH radically, it gets fully basic.

Fabian Fernandez: So that creates an area where basically it kills all the microorganisms that are in that retention zone. But there have been studies, actually a long time ago, where people have looked at the proliferation of soil microbes in that band, and yes, basically everything gets killed within that retention zone. But then actually you get an increase of microbial activity very soon after, a couple of days, a few days after, you start to get recolonization and it actually increases the amount of microbes, because you have more available carbon and nitrogen in that retention zone.

Fabian Fernandez: So that's the first one.

Carl Rosen: And just to kind of follow up, what happens is the ammonia kind of diffuses out, you get water, rainfall or irrigation, depending on the precipitation source, but anyway that dilutes it out and makes it more habitable for the microbes. And they see a readily available source of nitrogen then, and start using it along with the carbon in the soil.

Fabian Fernandez: That's right. And then as far as destroying the organic matter, that's also one that has been floating around for quite awhile. The only way that you can really measure these things is with long term studies. You can not measure these things from year to year. Organic matter is not something that changes drastically from a year to the next, or with changing of management practices. So you really need to look at these things over time.

Fabian Fernandez: The reason people talk about destroying organic matter, is the anhydrous ammonia does solubilize the organic matter, it makes it more available which also helps out with the microbial activity that we're talking about. So in reality, you can look at long term studies with nitrogen for like fertilization, and the net effect is an increase in organic matter. Because with nitrogen, you produce more biomass, which increases the amount of cycling of carbon back to the soil by having more biomass produced with the crops that you're growing. So that's the net effect is actually increasing organic matter rather than decreasing organic matter.

Fabian Fernandez: And then the other big one was, about soils being hard. So when I started my career, I was really puzzled by that. I was like, oh I don't know about that. So I started trying to figure this out, and then I talked to some of my colleagues that had more experience, and one of these colleagues had a lot of years of experience. He told me, well I think what happened is that back in World War II, they would use anhydrous ammonia to make runways, so they would apply the anhydrous ammonia because it will freeze the soil. Like I mentioned, when you apply anhydrous ammonia it freezes the soil. And they would use that to basically create a compacted area where you can land an airplane, because it's frozen soil. But that's the only thing, it doesn't create a change in bulk density or make the soil harder. Again, maybe a very temporary thing while the soil is frozen, but right after that it's not going to make a difference.

Fabian Fernandez: There have been plenty of studies showing that there is no change in bulk density or penetration resistance of the soil.

Dan Kaiser: And with anhydrous too, I mean, one of the things that does make it work well, as Fabian kind of eludes to here, with the microbial what happens around that injection zone, really is what makes it a very good fertilizer source, particularly for fall application. Because it really slows down at that point of where it's applied, that microbial activity, which will delay nitrification. Now it's not an inhibitor itself, but just that little bit of slowing seems to make it work a lot better than urea.

Dan Kaiser: I mean, urea in a band, I mean we're probably not seeing as much of a benefit as it would with anhydrous, just because of having what happens around there, particularly where it draws water out. It really has a big impact on the microbial activity. And the other thing with the microbes too, and this goes kind of with some things that I hear, in terms of some of these that I hear, in terms of some of these microbial products, these specialty products of adding to the soil, is we have a lot of microbes in the soil. So essentially, if you're adding something to the soil, you know, is it going to have any impact just based on the fact that there is far more there, it's like the drop of water in the ocean, in terms of what you're adding to there. Then in terms of recovery from anhydrous, I mean it's the same thing. We're not flooding the entire soil, having an impact where we're completely sterilizing the whole soil zone. So it will start to recover, and it can recover relatively quickly if the conditions are appropriate. So it isn't as if we're killing everything that's there, and that's really what I think is the main thing to remember. Yes, there is an impact, but overall I mean the system will recover, because that's just kind of the way it is.

Dan Kaiser: And with organic matter, you know, a lot of our issues with organic matter, if you look at where things have stabilized, have come from tillage. I mean the introduction I think of the air in there where we're changing what's going on within the soil, and that really tends to be where things moderate.

Dan Kaiser: So of these other practices, I mean really, haven't seemed to have that of a benefit or a drawback to that over time than we have particularly with tilling the soil and working it. I'm not a proponent for 100% no-till in there, but we know that you start reducing that, we start to see some organic matter change, particularly for the positive.

Fabian Fernandez: And drainage-

Dan Kaiser: And drainage, yeah.

Fabian Fernandez: Yeah. Tile drainage impacts how much irrigation you get into soil and how much the organic matter gets impacted by it.

Carl Rosen: Right. The oxygen stimulates the microbes, the microbes use the organic matter, and so you need to replenish that through biomass or some other organic amendment over time.

Fabian Fernandez: And just to make one quick point, what Dan was saying in terms of the total volume of the soil that gets impacted by anhydrous ammonia, it's a pretty small volume. Typically, you're looking at the ammonia retention zone is about three inches in diameter, depending on moisture conditions of the soil, and a little bit of the texture, but you know, three to maybe six inches at the most in a very dry soil, kind of sandy soil or dry soil. So it's a kind of limited amount of space that really gets impacted. And within that retention zone, the concentrations are very, very high at the point of injection, and they diffuse and become smaller as you move out of that center point.

Maggie Frazier: All right, last fact or fiction. Gypsum makes an excellent source of lime.

Dan Kaiser: This one, you know, it comes up every once in a while for the benefits of gypsum, but one thing that we know with a liming source is, really the calcium part, which is in gypsum, has no liming effect really. If you look at a regular AG limestone, which would be calcium carbonate or magnesium carbonate, it's really the carbonate component that has the effect on the liming. Other sources, that of oxides also are a liming source.

Dan Kaiser: So gypsum itself of the calcium sulfate, has no liming effect, even though it can affect pH in sodic soils, and it's typically used for remediation of sodic soils. But that's a whole different thing. We actually, [inaudible 00:25:25] of liming, that's where we're looking to bring the pH down, instead of normal liming, which is bringing it up.

Carl Rosen: It's not the sulfur that's doing that, it's the calcium displacing sodium and-

Dan Kaiser: Yeah, so sulfur by itself, now if we talk about other sulfur products, I mean, we really don't see a whole lot of liming with it. Ammonium sulfate is actually one of our more acidifying or most acidifying nitrogen sources. So actually it can have the negative impact we're talking about, pH and decreasing pH. Elemental sulfur also is used for pH decrease in gypsum by itself.

Carl Rosen: Gypsum by itself is considered a neutral salt, so just because it has calcium in there, it doesn't mean that it's a liming source. As Dan said, the lime is calcium carbonate, and it's the carbonate that does the neutralizing of the acidity. Gypsum, just because it has sulfate in there, the sulfur in there does not really acidify either. That's in the oxidized form, and so there's really no acidity being produced. Ammonium sulfate, the reason why that's acidifying, is because of the ammonium in there. And it's the ammonium that goes through that nitrification process that produces the acidity.

Carl Rosen: So gypsum we consider that a neutral salt. It's beneficial in sodic soils. It displaces sodium. It's also a calcium and a sulfur source. So, from that standpoint, if you need sulfur in your soil, gypsum is a source that can be applied.

Fabian Fernandez: And it's a byproduct of energy generation for the most part, and so it can be a useful source in that way, of using it as a byproduct, finding a use for a byproduct. But yeah, it has no relevance in terms of pH adjustment.

Dan Kaiser: Yeah, and sometimes the calcium is looked for providing some additional soil benefits, in terms of building soil structure. We've never really been able to prove that, although you end up hearing anecdotal evidence from growers about tillage through areas where they've applied it where it seems to till easier. I mean we can't really necessarily back that up. So right now, it is a fiction that it's a source of lime, but we view it as a moderately soluble source of sulfur. So there's some benefits out there for it, particularly for a lot of crops. So it's not that it's not worth applying, just don't view it as a liming source, it actually will not affect your pH at all.

Carl Rosen: It will not increase your pH, it will not act like a liming source, that is correct.

Maggie Frazier: All right, interesting discussion. We'd like to thank the Minnesota Agricultural Fertilizer Research and Education Council, AFREC, for supporting this podcast. For the latest information on nutrient management, you can follow us on Facebook and Twitter

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Maggie Frazier: Thanks for listening.