University of Minnesota Nutrient Management Podcast Episode "Nutrient interactions"

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(Music)

Paul McDivitt:

Welcome back to University of Minnesota Extension's Nutrient Management Podcast. I'm your host Paul McDivitt, communication specialist here at U of M Extension. Today on the podcast we're talking about nutrient interactions. We have three members of Extension's nutrient management team. Can we each give us a quick introduction?

Dan Kaiser:

This is Daniel Kaiser. I'm a nutrient management specialist with the University of Minnesota, located out of the St. Paul Campus. My specialization is in major macronutrients and their use in the majority of the commodity crop species across the State of Minnesota.

Fabian Fernandez:

I'm Fabian Fernandez, also a nutrient management specialist in the St. Paul Campus and my area of emphasis is in nitrogen management and environmental quality aspects of crop production.

Jeff Vetsch:

This is Jeff Vetsch, I'm a researcher at the Southern Research and Outreach Center here in Waseca and my emphasis is also in nitrogen management in crop production, primarily in corn and soybeans.

Paul McDivitt:

All right. So starting off, which nutrients are most important for crops and why?

Dan Kaiser:

Well, when you break down nutrients so we talk about two different categories. That being macronutrients, which are nutrients that the uptake is measured in pounds per acre and micronutrients, which the uptake typically is going to be less than a pound per acre. You're going to be looking at ounces per acre so there's not a lot of uptake although some of them can be a little bit more depending on whether or not the plant regulates the uptake of that particular nutrient. For macronutrients, we separate them into two categories, our primary macronutrients which would be nitrogen, phosphorus and potassium and our secondary macronutrients which traditionally have been calcium, magnesium and sulfur and the differentiation between the two really has to come, with the primary or secondary, come down to whether or not historically we need to apply fertilizer and are these nutrients are historically deficient within field.

Dan Kaiser:

So a lot of times you look historically sulfur as lumped as a secondary. I mean I almost put that as a primary right now just because of some of the responses we've seen out there but the micronutrients, the main ones, boron, copper, iron, manganese and zinc. There's some other ones out there like chloride, nickel, molybdenum, there's a few more maybe out there that I'm missing that some of them too which we consider beneficial. May not necessarily be quite needed by plants but may benefit their growth in one way, shape or form. So when you're looking at them, there's a number out there and I don't know Jeff, Fabian am I missing anything from that list?

Jeff Vetsch:

Iron in soybeans.

Dan Kaiser:

Oh, okay. Yeah, I thought I had said Iron and soybeans but we'll talk a little bit about this. We'll talk about interactions because said some of these micros, if you look at micronutrients, it really depends on the crop in terms of overall need for these and that's one of the main things with these nutrients. If you're looking at what you need to apply in a field, look at the crop and the sensitivity to a deficiency. We know that for many of our nutrients pH plays a very important role when it comes to nutrient availability but also we come in and look at a species' susceptibility to a deficiency is kind of key in terms

of determining whether or not these nutrients are going to be needed for application on a year to year basis.

Fabian Fernandez:

Just also a point of clarification, Paul you asked which nutrients are important, they're all important. The definition of macro and micro like Dan was talking about is important but they are all essential. Without those nutrients, the plant cannot complete its life cycle so even though maybe molybdenum is needed or boron is needed in a very small amount, without it the plant cannot complete the life cycle so they are all essential. And also just kind of as a point of reference that is kind of interesting, coming from Argentina originally, in Argentina sulfur is more of a primary macronutrient than potassium. We normally didn't really have issues with potassium, now we are having issues with potassium or starting to show up just like we are seeing sulfur issues in the US. In Argentina because of the soils and how they develop its actually kind of the opposite where potassium was not really a nutrient that you apply but sulfur is part of the regular recommendation.

Dan Kaiser:

And that's a good point Fabian because even with calcium and magnesium there are going to be situations out there where I would say particularly magnesium, we run into some situations where in Minnesota on some very sandy soils it can be deficient. The primary versus secondary really is kind of just more or less identified as Fabian was saying at the point of view at which your soils have the capacity to supply that nutrient on an annual basis. When we look at again Minnesota, I think again you put four of them up there, nitrogen, phosphorous, potassium, and sulfur depending on the crop are really kind of important because those are the things that more consistently we see fertilizer being applied to supply those nutrients to crops.

Paul McDivitt:

What are nutrient interactions and how important are they to crops?

Dan Kaiser:

Well, one of the things I guess to think about is when we start looking at the plant, we start talking about all these nutrients being important and that the plants aren't going to be able to complete their life cycle without them but when we start looking at it in terms of uptake is that these nutrients aren't necessarily being taken up independently of one another. So when we start talking about interactions,

what we can see is potentially some nutrients if they have a high availability may negatively or positively affect the availability of some other nutrients.

Dan Kaiser:

And one of the things I guess to throw out there that's I think a good example of this when it comes to interactions is Fabian mentioned iron earlier for soybean and with iron chlorosis, what can happen with nitrate. And one thing that we see in terms of nitrate, how it can affect chlorosis within a given field because if we start talking about nutrient uptake, if we get into anions like a nitrate, sulfate, chloride, some of those negatively charged particles that move into the plant with water. As a plant takes in one element in order to maintain the uptake of other elements, it has to maintain charge neutrality.

Dan Kaiser:

So in the case of nitrate, as it's taking in nitrate, soybean is typically releasing bicarbonate which can neutralize acidity around the roots and make iron less available. So there's a lot of things that can occur when one nutrient is being taken up by the plant that can affect the uptake of other nutrients.

Fabian Fernandez:

And one thing also to mention is that the mechanism of nutrient uptake there is passive nutrient uptake and there is active nutrient uptake and the plants are able to differentiate between different nutrients. A lot of times the problem with some of these interactions starts when there is too much like excessive amounts of one nutrient and not enough of another one. If fields are fertilized adequately typically you don't run into those issues, it's more of a problem when you just dump a whole bunch of one kind of nutrient and then things get out of balance. And I think this is important to keep in mind because when we start talking about balance, there are some folks that really worry about maintaining correct balance of ions and cations, anions in the soil and in reality I don't think it's that much of a problem if you are doing a good job in fertilizing, the problem starts when you are just dumping a lot of one thing and not sufficient of something else.

Jeff Vetsch:

Yeah. There's a couple of great examples as Dan mentioned, the antagonistic effects of nutrient interactions like too much nitrate in soybeans and high pH soil leading or contributing to excessive or greater iron chlorosis deficiency. And then also you hear circumstances where we've got too much phosphorus resulting in zinc deficiency in some soils but when we're talking about that situation, it has

to be phosphorous greatly in excess of agronomic levels as Fabian said. So it's kind of over the realm of what we would typically think as an agronomic critical value. It has to be much greater than that.

Fabian Fernandez:

Yeah and with phosphorus, that's actually a good example. Typically, we see really high phosphorus levels where there is manure application, not because of inorganic fertilizers. And when that happens, when the phosphorus is very high because of manure, that's typically not where you will see zinc deficiencies either because when you apply manure, you're also applying a fairly good amount of zinc. So the problem is when you're over fertilizing like you said Jeff, a huge amount of fertilizer as inorganic phosphorus and then you can start running into some of those interactions with zinc.

Dan Kaiser:

And I think that's a really good example that was brought up was with phosphorus and zinc. And we can talk about interactions of nutrients and how they're taken up or interactions within the plant but one of the other things that we can focus on as well is interactions within the soil, because while we know particularly the positive, the cations in the soil will be attracted and held on the cation exchange capacity. There's also anions floating out there that either can form ionic bonds with some of these elements or covalent bonds which I think tends to be what happens with phosphorus, where we have a lot of calcium or free iron and aluminum. They kind of interact and form aluminum phosphates, iron phosphates or calcium phosphates that have varying degrees of solubility in the soil, some which are not very soluble and render the phosphorous unavailable to plants.

Dan Kaiser:

I mean the main thing a lot of times when we look at our fertility program, you're looking at say your four nutrients or your three or whatever you're putting on and kind of putting them somewhat in silos but when they hit the soil, there's a lot of things that can happen. And phosphorous is one that we're looking at right now with a study funded through AFREC, looking at timing of fall versus spring application. And that's been an interesting study because I kind of expected to not see a lot of difference between fall and spring application but when I started looking at some of the higher pH soils, we are sampling the soil again in June after application, either in late October or early to mid November vs application in late April to early May, that there is a big difference in the soil test and what's happened.

Dan Kaiser:

So that leads you to kind of start thinking about how quickly some of these elements can react in the soil. And for corn especially, it's been interesting because it's been about six, seven bush of yield advantage for the spring application in these really high or these really low pH soil so below five. So these would be situations where there would be a greater capacity for that phosphorus to interact with zinc, iron, aluminum or calcium in the soil. So they're really a dynamic system when you start talking about interactions. In viewing things, we can do it somewhat to view them I think separately particularly with some of the major macronutrients but you get into some of these, especially interpretations for tissue analysis and a few other things that we have to kind of be careful since these things aren't necessarily independent of each other and how the plants utilizing them, taking them up or what's happening within the soil itself.

Paul McDivitt:

Which nutrient interactions are important and are of concern to crop producers?

Dan Kaiser:

Well, I think for me that P-zinc interaction that was brought up, it gets brought up a lot. I think as Fabian and both Jeff had mentioned though, what we typically see is you can induce a zinc deficiency by applying a high rate of P. Typically, it would take I think roughly about a thousand pounds of MAP or DAP on a soil that's already somewhat marginal in zinc to induce that deficiency.

Dan Kaiser:

And as Fabian was saying, if you look at your soil test particularly in a manured situation where I hear this a lot, people are concerned about the high P and in zinc is that if you look at your soil test, your soil test is a good index of availability. So if your zinc test is high, I'm far less concerned about say that phosphorous-zinc interaction versus if your zinc, your DDPA test might be around 0.5 or so, and then it might be something to kind of consider. But that's one I know that that comes up a lot and the other one that's been kind of more recent is this nitrogen by potassium too. And I don't know Jeff, we had some good comments I think before in terms of some thoughts on some of that with some of that N by K interactions.

Jeff Vetsch:

Well, I think we hear a lot from industry agronomists, especially seed agronomists about the importance of nitrogen uptake late in the reproductive stages of our modern hybrids. And it goes along with that

interaction with potassium, nitrogen and that stay green and that stock quality or stock strength and health of the plant. And whether that is critically important to high yield potential or not I think there's still some debate about that especially across areas of the corn belt, some hybrids maybe more so than others. But clearly there seems to be some relationship there between good K, sufficient K, nitrogen management, adequate nitrogen and then good stay green and hopefully maybe even something like interactions with fungicides in corn as well.

Dan Kaiser:

Yeah. And the other one I hear too at times is nitrogen by sulfur and I've looked at both the nitrogen by potassium, the nitrogen by sulfur. The nitrogen by potassium we had a couple of trials out on some irrigated sites, the issue with that was the years that we had it we were so limited in the nitrogen that I don't think it really mattered the potassium. I've also looked at nitrogen by phosphorus and the interesting thing about phosphorus is that if you look at say nitrogen phosphorus and potassium, that's the nutrient that tends to act seemingly more independently of the other nutrients. And I think a lot of that has to do with it's more actively taken up by the plant. So it's not kind of a passive uptake, more of a passive uptake mechanism so the plant has to expend energy to take it up.

Dan Kaiser:

So it seems to do it slightly differently for that and what I found with that was interesting is that if you looked at a nitrogen response curve at varying phosphorous levels, is that there was a definite yield hit and a consistent yield hit from the phosphorous across all my nitrogen rates. So you were taking a penalty for low N and low P but there was really no way which they can't substitute for each other but that sometimes you can see where it seemingly looks like that there's an interaction, you may be taking less of a yield hit at low of one nutrient versus another.

Dan Kaiser:

But it's interesting and in a lot of this I think you look at phosphorus in particular, you look at kind of how these things affect growth and in particular root growth and we see that I think a lot with low nitrogen, you get in situations, I actually have seen it with low phosphorus where we see a lot of nitrogen deficiency in the low phosphorus plots. And I think a lot of that has to do with poor root growth. So you've got probably enough nitrogen down there but the roots just aren't at the point at which where they're actively growing, they just can't get down to the point where that nitrogen is. So there's a lot of things I know with that and then with sulfur, what I saw is if we're deficient in nitrogen, it really doesn't matter.

Dan Kaiser:

I mean, that's the one that particularly corn production is going to hit you first and that was the interaction I saw between those two is that, and we really weren't seeing any sulfur advantage at low nitrogen levels just because it was just way too deficient but it's been interesting. And I know Jeff, some of the plots we've had at Waseca, some of the sulfur trials the last few years, looking at some of those control plots and continuous corn and seeing how nitrogen deficient they are and seeing the large yield differentials. I mean, it leads me to believe, you start looking at that and you just see how much things are set back if one nutrient isn't applied and how that can affect the other ones. It's just incredible.

Jeff Vetsch:

Yeah. And I think you touched on the exact key points Dan. Reduced tillage or conservation tillage which is pretty much widespread across most of the corn belt, corn on corn, those environments are the ones where sulfur just seems to be so critical and what seems like a minor deficiency can result in a huge yield response and it's obvious that that nutrient is interacting with nitrogen and the crop is just not performing right when it's sulfur deficient. It's not developing, it's not creating those proteins that it needs, and because of that it's a huge yield penalty.

Fabian Fernandez:

Yeah. I was also just thinking we don't hear too much sometimes about some of these, there are some that are a little bit more obscure in terms of either deficiencies or induced deficiencies. I remember back when I was doing my PhD in Indiana, looking at alfalfa with P and K and winter survival and the interaction that you have in those. If you go too heavy on one nutrient and not the other, you would actually have more winter kill of alfalfa than you will with not applying either P or K.

Fabian Fernandez:

And so again, I think the balance is important in terms of what you do agronomically of applying nutrients. The other one that I was also thinking about, again, it's been a number of years since I actually heard a case of but nitrogen induced deficiencies in soybean with a boron deficiency. The plants look like they are nitrogen deficient but in reality what is going on is that it was boron that was not available or in enough quantities available and that restricted the interaction with the nodules. So the nodules were not fixing nitrogen and so it looked like a nitrogen deficiency but it was really masking the fact that it was something else, it was boron or molybdenum.

Dan Kaiser:

And you can see that with toxicity issues too. I know if you look through a lot of the micronutrient toxicity problems and look at the actual symptomology, a lot of times the symptomology will mirror deficiency of another one of the micros. So you can get into situations where you could be diagnosing the wrong problem. So it's interesting you look at how well these things can interact and how one problem can mirror another one and it's just been as I said interesting looking at some of my fields. In the last few years the sulfur as Jeff kind of mentioned, it's one of the things I've seen quite a lot and we've been seeing 30, 40 bushel per acre yield increases in some of my check plots and I think a lot of that has to do with not necessarily that it's just sulfur alone, that it's sulfur and nitrogen interacting together.

Dan Kaiser:

And it's been interesting because I've been trying to get just clear pictures of sulfur deficiency on some late season corn in some of my zero sulfur plots and really what that takes is I've got to put on a really high rate of nitrogen to try to get rid of the nitrogen deficiency then I've been able to do it. But for the most part, I get out and look at my fields and my fields just look horribly nitrogen deficient because that's really one of the things that with plants is typically the most limiting factor. It kind of goes back to that Liebig's law of the minimum, is typically what's going to show up and even if it's one factor affecting another, if it affects the uptake of say nitrogen, you're likely probably going to see nitrogen deficiency show up in the plant versus maybe it's a different problem.

Jeff Vetsch:

Yeah, that was really interesting and Dan I think I sent a picture of some of your plots back in late may or early June from the tailgate of a pickup where you could see those plants, those sulfur check plots were visibly shorter. Well, clearly that was just that those plots were stunted growth and I would assume that was a nitrogen-sulfur interaction that was stunting their growth.

Paul McDivitt:

Do you have any tips for analyzing plant tissue to avoid misinterpreting results due to nutrient interactions?

Dan Kaiser:

This is a really good question because that's one of the things when we look at interactions, is that we do have to be somewhat careful if you're taking plant tissue samples, that you're not interpreting one thing as being deficient when it may necessarily be another thing. And kind of a few examples of this, if we start looking at say iron and phosphorus deficiency, sometimes we can actually see the concentrations be really high of these nutrients because the plants are so limited in growth they're still taking it up but because the plants are stunted in growth they can accumulate these elements in the plant tissue and it actually can be somewhat higher. But the main thing when I start looking at a lot of questions I get from growers on tissue analysis, what I'll typically do is work through them and start with what you suspect to be most deficient.

Dan Kaiser:

And that's really I think critical when trying to make some judgment calls and what to do within fields. It's just to make sure that you're starting with what is most likely to be deficient and then working your way down there because it isn't uncommon for me say nitrogen is lower, slightly deficient in some of these samples, to potentially see sulfur or potentially see some of the micronutrients become deficient or at least what we consider deficient based on the tissue analysis report. So that's one of the questions that comes out of that is whether or not if I correct the nitrogen will everything else fall back in line? So that's the thing with these interactions is you want to pay attention to some of the major ones. Another one that's out there that gets talked about a lot is a potassium and magnesium.

Dan Kaiser:

And if you look at your numbers for K and mag and particularly in plant tissue reports, you're going to see an inverse relationship. So if K goes up, magnesium goes down. If magnesium goes up, K goes down. You never really know. There's I think some debate whether or not, that's related to soil availability and high mag situations. I think a lot of that has to do with potassium availability because if you look at high K availability, you'll drive it down below, K availability will drive magnesium up. It seems like the plant is compensating for the deficiency of one by taking up another one. So it's one of the things to just be aware of, kind of what's there and then also just be careful so that you're not buying inputs that you don't potentially need in correcting the problem that isn't necessarily the problem that you need to be correcting.

Fabian Fernandez:

Yeah. And another thing with tissue testing too that I often hear is that people are going to a book value to see if they have an issue or a problem with their concentrations and oftentimes the concentrations that they are looking at from a book, they represent different plant part or an earlier or later development station what they have in the field and that it's really trying to compare apples to oranges. There is no way to really use that information and so if you don't have a test value that matches what you have as a reference, the best thing that I normally tell growers to do is to sample areas in the field where they see the problem and areas where they don't see the problem, so that that way at least they can have a diagnostic with a similar plant materials and similar development stages.

Dan Kaiser:

Yeah and that's one thing they see a lot too because if you look at a lot of our data, I've collected quite a bit of plant tissue data in my time here in Minnesota. We've looked at a lot of things, particularly interactions with hybrids and varieties in their environment and there's a lot of things that can occur inside of the plant. The plant gets stressed, I mean it may take up one nutrient. One might accumulate, another may not necessarily be utilized or it may decline. So there's a lot of things that occur because again these things are dynamic. It's not a static system, the plant is taking up multiple nutrients, they all affect each other and again they're all kind of essentially at the mercy of the environment that that plants growing and that makes it kind of a mess.

Dan Kaiser:

And we're trying to then make a judgment call on what set number if you're above or below this fine line as a cutoff point of whether you're good or bad, it becomes difficult. and I think that's why more recently I get a lot more reports on boron being deficient. It's some of this interaction with environment and if you get to dry weather conditions, uptake can be slowed of that particular nutrient and it wouldn't surprise me to see more samples come back low even though it probably isn't anything to do with the fact that the boron was needed in those fields. It's just essentially that at that key point in time you're getting a snapshot in time that just wasn't necessarily available or it wasn't going to that plant part. So this is kind of the thing with interactions, as I said we talk about interactions with nutrients against each other, but gee it's so much more of a dynamic system in terms of the plant, how it interacts in the environment itself.

Dan Kaiser:

So it's one of the things I just really stress. If you have questions and you get reports back and something seems a little bit funny out there is that there are differences in kind of opinions on sufficiency values and a lot of that has to do with a lot of what Fabian was talking about. Essentially is a lot of these

numbers are really set for a particular part sample at a particular time and that's really important to remember when you're taking samples, that you're not just going out there and grabbing any samples you want out of the field. You have to have a really good plan in terms of what you're doing to make sure you're getting the most out of your results.

Fabian Fernandez:

Yeah. And in general, talking about environmental conditions in general, the concentrations go down as the plant gets bigger. So that happens just under normal conditions but it also happens when you have very fast growth. For instance, it's not unusual with the corn, soybean that we plant when it's cool, it doesn't really grow very well and then all of a sudden it starts growing really fast because conditions really improve. It gets good sunlight and temperatures and the plants just really shoot up really fast and then the concentrations drop quickly and that's typically where we see some of the major issues. Is that those concentrations get diluted and people start wondering why they're so low when in reality it's just a dilution effect given by the growth of the plant.

Dan Kaiser:

And I see that with K a lot. Some of my really high yielding sites a lot of times you'll see you'll take your leaf tissue and the numbers will be really low. And I think it's just as Fabian said, dilution effect. So it's one of the things to kind of watch out for on that, that it's just not necessarily that it's needed. It just the plant is utilizing it more efficiently or more effectively so as the plant ages you're going to see the concentrations decline as well as the seed is being developed because a lot of the efforts by the plant is going to be put into developing that seed. So it's one of the things you just have a plan and make sure you know what you're doing and not just going out there and just taking random samples because you may not have a good understanding of what you get back because it may not make a whole lot of sense just because it's not sampled correctly.

Jeff Vetsch:

And the other thing we sometimes see not only in the tissue but also in the grain is the luxury consumption. Nutrients like potassium and phosphorus in particular, the plant can take up excess, more than it needs and have a higher concentration, significantly higher than its critical value. And that can result in higher concentrations of removal in the grain even though the crop really doesn't need all that, it just it's utilizing it and taking it up anyway.

Paul McDivitt:

Any last words from the group?

Dan Kaiser:

Well, just as I said before, if you have any questions, if you get a soil test report back, that's what we're here for as Extension specialists. Just ask us if you're wondering on any of these interactions that may be going on in the field. I mean, tissue analysis is a good way to look at if you've got a problem area of the field but it isn't always straightforward because of some things that can happen within the plant but we're here for that and to answer questions on some of this stuff. So it's one of the things I'd encourage anybody if they're looking for a secondary opinion and just want a second just judgment on what's going on with some of their samples. Feel free to give us a call or drop us an email.

Fabian Fernandez:

Yeah. And I would just say that the tissue sample is basically one tool in the toolbox and that's the way we should look at it. We should never look at it as the sole source of information when we have a problem that is developing in the field. Use that against everything else that you may have whether it's soil testing information, weather conditions, has this problem happened before. All that information is really important to kind of put it all together to come to an understanding of what may be happening. So don't take it for the face value at first glance because there could be a lot of misleading issues with that.

Jeff Vetsch:

And I think I would say that if you think there's a nutrient interaction that's limiting your crop growth or your yield in a field, it probably has to be one of those two or three common ones that we mentioned. It's probably not anything that's too unusual or something that we didn't discuss because they're just not very likely.

Paul McDivitt:

All right. That about does it for the podcast this week. We'd like to thank the Agricultural Fertilizer Research and Education Council, AFREC for supporting the podcast. Thanks for listening.
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