

# University of Minnesota Nutrient Management Podcast Episode: “2023 AFREC research roundup”

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(Music)

Welcome back to University of Minnesota Extension’s Nutrient Management Podcast. I’m your host, Jack Wilcox, communications generalist here at U of M Extension. This episode is our 2023 AFREC research roundup. We have four panelists here with us today. Can you each give us a quick introduction?

**Daniel Kaiser:**

This is Daniel Kaiser. I'm a nutrient management specialist with the University of Minnesota Extension. I'm located on the St. Paul Campus.

**Jeff Vetsch:**

This is Jeff Vetsch. I'm a researcher. I study nutrient management at the Southern Research and Outreach Center in Waseca.

**Lindsay Pease:**

I'm Lindsay Pease. I'm an assistant professor and extension specialist in Nutrient and Water Management, and I'm at the Northwest Research and Outreach Center in Crookston.

**Fabian Fernandez:**

And I am Fabian Fernandez, also a nutrient management specialist with research and extension responsibilities at the St. Paul Campus.

**Jack Wilcox:**

**What is AFREC and how does it help you conduct your research?**

**Daniel Kaiser:**

Well, AFREC is the Minnesota Agricultural Fertilizer Research and Education Council. I don't know, can't remember exactly the year, but it was back about when I started in around 2008 AFREC was formed, which essentially is funded based on fees for tonnage of fertilizer sold, that was put into a pot to put forth competitive grant in just some baseline soil fertility research. And that's one of the things if you look at around the country for research for just doing work related to fertilizer guidelines is that the pool of money really isn't that large. If you look at federal grants, federal grants typically won't go after projects that are just real applied projects that funnel into some of our fertilizer guidelines. And that's kind of when we start looking at, for somebody like me that my whole position here really is based on evaluating fertilizer guidelines. This money's been invaluable, at least to get some baseline research in place to look at evaluating the guidelines.

And that's one of the things a lot of growers are always interested in, as yields continue to creep up how our fertilizer guidelines perform. Do we need to be looking at increasing fertilizer rates? So having a pool of money that we can access for long-term projects specifically is really critical for some of this. Because a lot of the work that I do doesn't necessarily focus on a single crop, it looks at fertilizer applications within rotation. So that's been one of the key benefits of having this program around, is being able to look at things over a longer period of time and getting to some real applied research questions that growers are asking on a year to year basis.

**Jeff Vetsch:**

As a researcher at one of the ROCs, it's really great because it's very applied and it allows you to do some reactive type things that are on hot button items that people give you questions about all the time. But also, as Dan said, some of those long-term proactive projects are also fit into this system very well. And I think that the council, the people that oversee the grant process recognize that and value that.

**Fabian Fernandez:**

One of the other interesting things about AFREC and what allows us to do with research is, Dan mentioned a lot of the federal grants that are not so much focus on very applied questions that we need the answers for before we can actually go into those bigger parts of money that the federal grants typically try to target. It's actually kind of interesting, I have been in federal grants and in reviewing federal grant applications, and you'll see in these applications where they may say, "We are going to test X, Y, or Z." And one of those variables is the university guidelines, or "We will use these treatments and apply university guidelines for the crops that we are growing." Or things like that. And it is almost a given that, well, those things are there in place, but the reality of it is that the only reason those guidelines from the university are in place is because of this money that we have through AFREC funding to be able to do the background work to have that information.

And then the other part is often federal grant for instance, they will be short in time, which doesn't really allow you to do a lot of the things that sometimes is required. As Dan mentioned, one of the benefits of AFREC is that it allows us to look at things longer term. And that's one of the benefits also of having these kinds of funding, is that as you start these projects long-term, then federal grants typically then to be focused on answering one specific question, but you can only answer that question if you have a system in place that has been there for quite a long time in order to answer those questions. And without a long-term background, you cannot really get to those questions that make bigger grants are interested in. So it really is extremely beneficial to answer the day-to-day questions like Jeff was talking about. But it's also really important to leave the background work that is needed to then be able to find more in-depth answers to some of the scientific questions that are out there.

**Lindsay Pease:**

What I really think is cool about AFREC is that that's the money that the council, AFREC Council, they have us go through this review process and we really look at how we can reinvest those dollars and thinking about how we can help make the fertilizer applications and the fertilizer purchases that farmers are making a good return on investment. So really we're looking at making fertilizer application more efficient, and this council is made up of groups from representatives from all across the industries, from the different commodity groups and from the state government. So it's a really great way to come together and to make sure that we're putting our dollars in the right place in terms of our ag industry.

**Jack Wilcox:**

**What AFREC funded projects are you all currently working on? And are there any interesting findings from the 2023 growing season?**

**Daniel Kaiser:**

Well, I can start a little bit about what I've been doing. A lot of the work I've been doing with the council has been focused on sulfur. There has been a lot of interest from a lot of the members on the council looking at various aspects of sulfur fertilization. And that's one, if you look at some of the early work we did with AFREC was looking at sulfur and we had identified some areas that growers were likely under applying, which it's kind of one of the big focuses of some of this stuff. While there is money feeding in from what the growers are paying on a tonnage wise to the program, I mean the end result hopefully is some data that they can at least increase profitability where that would more than pay for some of what that investment in fertilizer is. So sulfur has been the main one that I've been looking at and a lot of the focus of my work has been looking at in rotations.

And again, looking at long-term over time, we know that sulfur can leach, it's just not as leachable as nitrate. And there are multi-year benefits and that's some of the things we're starting to see with some of the projects. So that's one of the larger areas that I've been working on with AFREC. One of the other areas has been looking at potassium. I'm looking at refining our guidelines for both corn and soybean production. The key component I'm looking at right now are timing, looking at fall and spring application. We did this with phosphorus for a few years, looking at the overall efficiency and looking at phosphorus, seeing more differences in fall versus spring application. That's one thing that we did come up with particularly for corn, that growers that have a low phosphorus soil test or high pH soils that seemed like spring application was a definite yield advantage.

But potassium we are not seeing all that much. But again, a lot of the things that I do may have some questions that we get from growers like that with that timing component, but we can implement some rates within that timing, some of the treatments to try to get some multi benefits out of it. So some of this data that we can look at, at least from the rates side, looking at evaluating some of our current recommendations. So that's my main... This last year, potassium, it's been one of the things I've been telling a lot of growers is don't forget about it, these dry years. And we've been seeing it the last few years with some of the research of having it in place, seeing some especially last year, more consistent responses in my corn sites, in my soybean sites, but with dry weather conditions, seeing some lowering soil tests. So that's been one of the, I think the main interesting thing on my side. The sulfur data where, at least one of the trial's starting to answer some questions on some of the different sources that are out there.

And I'm probably not going to get too much into that here, but if you haven't subscribed to Minnesota Crop News, we'll likely have some updates of that coming forward. And I'll be talking about some of that data at our upcoming nutrient management conference. But just some interesting things on that and to start addressing some questions that I've had in terms of what some of the optimal rates are. So that's about all I can say. I mean, having these dry years hopefully get into some more normal years, at least with rainfall, just see some different things in both of those. And that's kind of why it's nice having the funding that goes across years, where we can maybe hopefully catch some of these differences that we'd see with some different environmental conditions.

**Jeff Vetsch:**

I'm a co-PI or a collaborator on several AFREC projects. In 2023 as a PI on one study. And it was looking at the current to measure the effects of cover crops and nitrogen rates on corn production, nitrogen loss and tile drainage and soil health parameters in corn grain and corn silage cropping systems. Interesting facts or findings from this study, we didn't have great cover crop establishment and growth in the fall of 2022 going into the 2023 growing season. This was partly due to just very minimal rainfall, less than a half an inch total in the six weeks after we seeded the cover crops. From a tile drain standpoint, most of the 12 inches of tile drainage we received in 2023 came in late March, April and May. We had a large rainfall event about six inches here in south central Minnesota in a week time in early May, and that drove a lot of our drainage.

In April, nitrate concentrations in tile drainage averaged about nine part per million in corn silage systems and about seven and a half in corn grain systems. And these values were pretty low compared to what we typically see for continuous corn. But in May, the nitrate concentrations increased to 13.4 part per million in corn silage, but we're still only about eight part per million in corn grain. And this is interesting because only about 20 pounds of the N was applied in that cropping season in the month of May because the planting was delayed to May 22nd. So all that other N that was coming out of those tile drains was probably either a little bit leftover from the previous year or mineralized from the spring in that corn silage system and that's where we saw the bump in nitrate concentrations.

**Lindsay Pease:**

I have three different AFREC projects for 2023. And the first one to build on Jeff's answer, he was just talking about tile drainage and one of my projects is also about subsurface tile drainage. And what specifically we're looking at as part of the AFREC funded portion of this project is how the installation of a new drainage system, which we did in 2019, how that may or may not change the fertility recommendations. And of course, with the sort of three drier years that we've had, we haven't seen a lot of water moving through those drain tiles as you can imagine. But I do think we are starting to see some of those nutrient losses in tile drainage systems. It's not fertilizer in fertilizer out the same year. A lot of the times that nitrogen is getting tied up, it's getting cycled into the system. And so we saw, we can still see nitrate losses even in a soybean year where we haven't applied any extra nitrogen.

But I do think the main message that we've seen is that we do not need to revise our fertility for tile drainage systems after the installation, at least not immediately. The second project I'm working on is along those similar lines, when you add a big change to your system, how do you need to incorporate that change into your fertility systems? And we are looking at strip tilling and adding cover crops into a sugar beet system, which sugar beet systems usually have a lot of tillage involved. And so there's not a lot of crop residue that's left in those sugar beet systems.

So when you're adding this source of carbon in the crop residue, I'm really interested in looking at then how that affects how much nitrogen is available in the timing of that. Now, one thing I will say is it would just after one year of data, we don't have really conclusive results yet, but I am seeing some effect of higher amounts of residue tying up some of the nitrogen and not translating into sugar yield at the end of the year, which of course is not great news for the beet growers.

But what I do think we can learn a lot from, and we did learn a lot from this year, is that that residue management, managing those cover crops early, terminating them before they get out

of control. We had a little bit of growth out of control this year, which I think contributed to that. So I'm really looking forward to continuing that hopefully next year and getting some more conclusive answers on we need this nitrogen available at this time. The third project that I am working on is actually kind of completely different from the others. This one is looking at revising fertility guidelines for the cultivated wild rice growers in Minnesota.

And this is a group that is mostly centered in north-central Minnesota. So a little bit outside of my regular northwest Minnesota territory, but still in the northern part of Minnesota. And something that's really interesting about these systems is that you're actually farming them underwater most of the time. And so the implications on how you apply a fertilizer in that system makes it a really interesting question to look at and how we make sure that those fertilizer applications are efficient and then also not getting released back into the environment.

**Fabian Fernandez:**

And so I have a number of projects as well funded through AFREC, and some of them are continuation, some of them just have finished and some of them are new. I submit new projects all the time as well, just like my colleagues. And one thing that I was thinking about AFREC and the significance of AFREC, and I thought in order to answer some of these questions, it would be, I think, helpful to have a little bit of a history lesson here. The Morrill Act of 1862 when Abraham Lincoln was a president, that's what established the land grant universities. Each state received federal land grant to sell that land and with that establish a university, a land grant university in each state. And in 1887, Congress then approved funding for the Research Act experiment station, and that was the Hatch Act. And what that allowed the universities to do was, okay, we have the universities, they were tasked with the importance of teaching classes in agriculture and military science and engineering primarily.

But then it didn't take very long for people to realize that, okay, now we have a university, we are teaching great classes, we are doing a lot of great research, but the end users are not being told about this research and these findings. And so what AFREC allows us to do as a land grant university is to do research locally and then be able to extend that knowledge to the people that will use it. And so I have research across the state. That's one of the wonderful things of AFREC, is that it funds research that covers the geography of this state.

As I mentioned, I work primarily with nitrogen. And so I established a study back in 2019. This is a long-term study where we are looking simply at nitrogen rate and trying to understand the impact of nitrogen rate from year to year. If you apply the same amount of nitrogen, whether it is as suboptimal rate, an optimal or above optimal rate, what happens to crop production, what happens to soil nitrogen and the ability of the soil to produce crops.

And as I was mentioning at the beginning, these long-term projects are extremely important because nobody's really interested, the big grants that we normally talk about, nobody's really interested in funding this kind of background work. Once those plots are established and are established for the long term, they allow us to answer really important questions that you cannot answer by just simply going to a field and taking some samples. You need to have those treatments in place for quite a long time to develop those conditions.

We also have projects looking at the effect of nitrogen timing and source and placement, actually under different tillage conditions and soil drainage conditions. All of my projects that are currently being funded or have been funded through AFREC kind of look at those four variables

of looking at the rate, the source, the timing, and the placement of nitrogen to improve the efficient use of these fertilizers.

And then the last part is AFREC is also providing funds to support two conferences where we use a lot of the speakers that participate in this conferences where a lot of the research that is being funded through AFREC has an outlet so that crop consultants, farmers, the industry has access to the latest information that is coming out of these projects.

The other really important part that AFREC has allowed me to do is to look specifically at environmental outcomes of what happens with nutrient management. I have been looking very intensively at nitrate leaching into both groundwater and surface waters that impact the Gulf of Mexico, impacts Lake Winnipeg to the north and lakes locally as well as the groundwater. And then emissions of nitrogen to the atmosphere as nitrous oxide or ammonia emissions that impact global warming and things like that. So again, it's really kind of all encompassing what AFREC allows us to do in the state of Minnesota.

And again, going back to the little bit of a history lesson about how the land grant universities came to be, I have been in many other countries where this system is not in place, where there is not a vehicle to do the research, the teaching, and then extending that knowledge out to end users. And that void is definitely filled, but it's unfortunately filled by people that have their own interests, their own agendas, and that benefit of the land grant having been a source of unbiased information doesn't exist. And you can see some of the issues that that can create. And so having this funding, local funding through AFREC really, really helps us in many different ways, not only in just doing the research, but also in really improving the livelihood of everyone in Minnesota.

**Jack Wilcox:**

**Everybody, what's been your favorite AFREC research project and why?**

**Daniel Kaiser:**

I think the ones that I like most are the ones that by the time you're done, it maybe gives you maybe some things that you hadn't thought about to use for future projects. The one I can think about is a project they started, it was back around 2010 or 2011 that we were looking at combinations of phosphorus, potassium and sulfur before corn and how that affected the corn. And then the following soybean year where we didn't apply any fertilizer, where we track that over a six year timeframe. And one of the things that came out of that is I started to think a little bit about some of that sulfur contamination that's still in the fertilizer because I was seeing some things that were weird with the phosphorus side where we're looking like we're getting sulfur responses.

So it's things like that that where you take a question, how you develop a study? Then you start to get that study and get further down the line where you start to see things that you didn't expect that lead into other projects. And that's one of the things I like doing, because the nice thing about this, depending on how it's structured is that we're fairly well-connected with industry just based on how the council is structured, that you get some questions here and there, and some things that they're interested in, some things that you maybe never thought about looking at that tend to be something that spurs future studies.

Where now I've got this current study where I'm looking at different sulfur sources where I've taken some of what I learned from there to kind of put towards this to try to look at sulfur cycling,

getting more of a basic understanding of what's happening in the soil that may not necessarily be of high interest to some of the growers, but it does factor into some of the things that they should be considering for some of their fertilizer purchases or their fertilizer application rates. So it's one of the ones that I can think of just off the top of my head just because of how that was structured and some of the things that it's nice where you have this building where you start with one question and it leads into others.

**Jeff Vetsch:**

One of my favorites was the long-term phosphorus study. And the reason for it was several of us nutrient management specialists worked on it together. It was at six locations on key soils across the state of Minnesota, including five of the ROCs. The research data that we collected validated our phosphorus guidelines at a time when a lot of people were questioning and said they were outdated and they were reducing crop yields. And it really showed that that was not the case, that they were valid and were still very much needed and could be used and still maintain high yields.

**Lindsay Pease:**

I will say one of my favorites so far is the drainage plot study, which of course, if any of you listening out there have seen me speak in the last year or so, you've absolutely heard me talk about Minnesota's coolest drainage plots. Because we are the coolest, we're the furthest north. I can't claim coolest in all North America because of our friends in Manitoba, but I can't claim coolest in Minnesota. And I'll say the support from AFREC on that, this project will always hold a special place for me because that early support from AFREC, I mean, I was brand new as a researcher and they really saw my vision, they were interested in seeing how this drainage system might affect fertilizer recommendations.

And really gave me that early vote of confidence that I have been able to use and to leverage. And this has become a really major part of my entire research programming at University of Minnesota. And it's that early support and that early vote of confidence from AFREC has really helped me leverage other opportunities, including longer term funding from The Fertilizer Institute to keep this research going. So that's just an example of how this council can really help boost and make a bigger impact long term.

**Fabian Fernandez:**

But Jack, your question is kind of interesting because, what is your favorite project? This is kind of like saying which one is your favorite child? You love them all the same, but your favorite kind of change from day to day or hour to hour sometimes. And so this is kind how I feel about my projects, because I really have loved all of them. The favorite has to do with the circumstance. For instance, we did a urea study a number of years ago, and what I loved about that project, and it was my favorite, is that it was very timely.

They were very specific questions about doing applications of urea in the fall and whether that was an okay practice or not. And it happened right at the time when a lot of the industry was switching from anhydrous ammonia to using urea. And so having that information at that time was critical. I loved that project for that reason. And again, it was a project across the state with several collaborators. If we are talking about looking at enhanced efficiency fertilizers and improving management of nitrogen, what we do with nitrogen and the impact that that has on environmental quality, I would say the drainage project that I had in Lamberton through AFREC funding. And again, that was actually a good example of a project that was started with an idea

that nobody would've been interested in. AFREC funded it and then we were able to secure funds through a national agency to continue some of that work later.

So between that project and the fact that I've been able to look at how people are using that information through these conferences that we organized, I have been able to piece together basically the kind of impact that this information has, how much of what we are producing is reducing nitrogen losses to the environment, and then figuring out how much farmers are using this information in their own farms so that they can reduce their nitrogen losses and then be able to calculate what that is in a composite for the state.

And it's huge. The impact that these dollars that are from AFREC have on the state and beyond, it's just amazing. And then if I had to think about projects that are my favorite because of collaboration, that would be the long-term nitrogen study that I mentioned earlier, where everybody in this podcast and many others are part of. I love the fact this is kind of our project that Jeff and Dan talked about that with phosphorus. This is kind of like that too in the sense that pretty much everyone in the nutrient management team is involved one way or another. And I love that.

**Jack Wilcox:**

**What would happen if AFREC were to go away?**

**Daniel Kaiser:**

Well, I think certainly you look at the amount of funding that we have and the amount of projects specific for me that I've had, that's been crucial for a lot of the work that I do with evaluation of our fertilizer guidelines. So if we didn't have that funding, that would limit a lot of that work. And Fabian hit this nail on the head with a lot of this that, while we have a lot of focus looking at economics, there's also some environmental pieces focused in on a lot of this. So we've been able to merge the two. And the other benefit that we've had with I think a lot of this program is really fostering collaborations among all of us doing work across the state. Because we've got a large state here in Minnesota, and you've got researchers like Lindsay that are all the way up in the northwest that some of their conditions are different.

But having some funding where we can foster collaborations on this where we all can, even if we have disagreements, set up a project that would answer some of the questions, what we disagree on, we could do that across the state and try to look at multiple areas and just trying to focus on one area where all of us have most of our research. That's been, I think that the key for me really has been some of these collaborative projects, that it's allowed us to do more with those. And also on the outreach side, because I mean, certainly this podcast is made possible by dollars through AFREC because of some of what AFREC's funded for outreach. And it's been one of the key things in the last five or so years where we've really expanded on getting the information out to growers. And that's been one of our core things that we've been trying to work on, is getting the information to those in the end that would use it.

So I think the big thing right there, is what it's allowed us to do, not only in expanding the research side, but also then expanding and getting that information out to the end user, which throughout our extension program, we do talk to a lot of people, but we don't always get to everybody and all the farmers. It's interesting just some of the people that aren't necessarily coming to some of the extension events that we'll call or email that heard some information regarding some of what we've been doing, because it's either been published in a newspaper or somewhere that they read that we've been able to get that information out. It's really been, I



think one of the big things that I think we would lose some out on without having some of this funding we have right now.

**Jeff Vetsch:**

Yeah, I would probably say that I try not to think about it going away. But it would definitely reduce the number of applied soil fertility projects that we have, not only here at the Southern Research and Outreach Center, but across the state. And I think that'd be a bad thing. And I agree with what Dan mentioned, it's spot on is that even though the AFREC program is a competitive grant program, it's actually worked to really help us work and be more collaborative as a group. And I think that's been the huge positive that I can see.

**Lindsay Pease:**

Yeah, and one of the things I think about if AFREC were to go away is then we would start to see a lot more, I think you'd see a lot more commodity specific projects happening. Because if you're growing corn, then the corn growers want to really focus on corn projects or soybeans want to focus on soybean projects. And that's not exclusive, it's not the only thing, but I think what AFR does is it really allows us to work across cropping systems, because hardly anyone is growing only one thing, everything is in a rotation with something else. And we can really start to dig into those longer term questions as been brought up. And I just want to second to the communication aspect. The support from AFREC especially on the communication side, has been invaluable.

**Fabian Fernandez:**

Yeah, sometimes it's easier to think about what you have, if you think about what it would look like if we didn't have that. And like I say, I have been in many different parts of the world. I actually did a sabbatical specifically focused on trying to understand some of these things in other countries. And I can tell you that we are extremely fortunate in Minnesota and in other states in the US where programs like this exist, because this information, if it's not in place, it's the Wild West in terms of nutrient management. It is the Wild West. People will do whatever they think is best or whatever somebody that's trying to sell them a fertilizer says that it's best. So without that research background, it's anybody's guess what is the right amount of fertilizer, for instance, or what is the appropriate thing to do with fertilizers. And as we know very well too, is if you are not managing nutrients correctly, then you could have a huge environmental impact.

Recently I was looking just quickly, and this is one little fraction of what we are doing. But in my little world of just looking at one project and kind of following through with information from surveys of what farmers are doing with the information they provided out of that one project alone, I calculated that approximately about \$130 million of revenue in income come to Minnesota because of a small change in practice that we found out that it works very well based on that information and the fact that the percentage of farmers that are saying, yes, I'm using that, or I'll be using that. Similarly with a different project looking at environmental quality, several tons of nitrogen that are lost to the atmosphere were reduced yearly because of the change that farmers are implementing based on some of the research that we are doing. And so the impact is huge, whether you see it or not.

I mean, you don't really see 3 million tons of fertilizer. You may not see the impact directly, but it a huge impact that is happening down the stream. And so if this program were not to be in place, it will be extremely problematic in many regards. And then the other part that I know that I am biased here, but we have, you look across the US universities with people doing research in nutrient. I would say the University of Minnesota is number one or pretty close to the top in

terms of the number of people that are doing research, really good research. And most of that is happening in nutrient management because of funding such as AFREC and local groups that are providing funding to do some of these really important work.

**Jeff Vetsch:**

One thing I'd like to add is even though our panel today consists of all nutrient management specialists, it's not just nutrient management people that have tapped into this resource, we've collaborated with agronomy, people from agronomy, plant genetics here at this University of Minnesota, but also our collaborations have been with some of the industry people as well, and not only just in the fertilizer industry, but just all of the crop production industry. And I think that's a key thing. And those members, as Lindsay mentioned earlier, sit on that council.

**Daniel Kaiser:**

And one of the other things too, I want to hit on what Lindsay said is, I don't want to downplay some of the support that we have from some of the other commodity groups, the corn growers, the soybean growers, the wheat growers, sugar beet growers, potato growers, dry bean growers. I mean, they all have requests for proposals that will fund research projects. But the nice thing about AFREC is that tends to integrate a lot of these things so we can look at things. And it also supports some of those things like some of what Lindsay's working on with wild rice that may not have support yet they purchased fertilizer. So that's one of the things that having this that overarches everything else, I think is really key because it does help supplement, but also bolster some of the work we're doing on that where you can look at some other things that we may not necessarily be able to do with funding that's generously supplied by some of these other funding sources.

**Fabian Fernandez:**

And in addition Dan, I was just thinking in addition to all the stuff that you mentioned, the different cropping systems, cover crops, there is a lot of interest in having green cover in the ground. Well, if you have a cover crop, what does that do to production, what does that do to nutrient management? There are a lot of people that are interested in having these things, but there are a lot of questions and there are no answers if we don't do the research. And so that allows us to not only look at production crops that are cash crops, but also everything else that works in concert with the cropping system. Tillage is another one, soil drainage, as we talked about, all of these things are integrated into what we do with nutrient management and AFREC helps us to fund research that looks at all of these variables along with nutrient.

**Jack Wilcox:**

**Be sure to attend either the upcoming Nitrogen conference on Feb 13, 2024, or the Nutrient Management conference on Feb 20, 2024. For more information or to register please visit [z.umn.edu/2024conferences](https://z.umn.edu/2024conferences). That's [z.umn.edu/2024conferences](https://z.umn.edu/2024conferences).**

That about does it for this episode of the Nutrient Management Podcast. We'd like to thank the Agricultural Fertilizer Research and Education Council or AFREC for supporting the podcast. Thanks for listening.