Nitrogen loss: Lessons learned from the 2024 growing season

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University of Minnesota Nutrient Management Podcast Episode:
“Nitrogen loss: Lessons learned from the 2024 growing season”

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(Music)

Jack Wilcox:
Welcome back to University of Minnesota Extension's Nutrient Management podcast. I'm Jack Wilcox at the communications desk here at Extension.

Today we have a big topic: nitrogen loss lessons learned from 2023 to 2024. We have 5 panelists from across the state joining us today. Could you each please introduce yourselves?

Fabian Fernandez:
I'm Fabian Fernandez, a nutrient management specialist, based in the Saint Paul campus. I do research and extension in nitrogen management for coral cropping systems.

Jeff Strock:
This is Jeff Strock, soil scientist, strongly southwest research and outreach center near Lamberton, kinda covering southwest Minnesota.

Jeff Vetsch:
This is Jeff Vetsch. I'm a researcher, and I cover south central Minnesota at the research and outreach center in Waseca.

Lindsay Pease:
I'm Lindsay Pease. I'm a nutrient and water management specialist based out of the Northwest Research and Outreach Center in Crookston.

Brad Carlson:
Brad Carlson, extension educator in water resources, then, nitrogen management out of the regional office in Mankato.

Jack Wilcox:
What N application practices look particularly bad in 2024?

Jeff Vetsch:
Yeah. At least in our area here in South Central Minnesota, and I think also in Southwest or West Central from what I heard, pretty much anything that was applied in the fall, whether it was manure or fertilizer nitrogen, a lot of those fields did not look very good. We had a study that we initiated last fall in collaboration with Aaron Cortes, Melissa Wilson, and a couple faculty from Stalto State University. And in this study, we had fall liquid swine manure application, with or without starter fertilizer. And then we had a pre plant urea or pre plant fertilizer.

So kind of comparing manure to fertilizer both from a crop production and a soil health standpoint. And interestingly, the fall liquid swine manures, those two treatments, one yielded 137, the other one was a 147 bushels and the pre plant urea was 177. So a huge difference with spring applied and as urea compared to that fall applied liquid swine manure. And they were applied at what should have been equal plant available nitrogen rates. And interestingly, I think the liquid swine manure was applied pretty late November 10th.

But we still had that kind of losses in that field to nitrogen with that fall manure application.

Fabian Fernandez:
You know, I agree with that. Pretty much, in most parts of the state, the fall stuff really looked bad. The southeast is maybe the exception, and the other ones were I guess, because people don't apply nitrogen in the fall, or at least they shouldn't, in a lot of those places. The other one, of course, is the sands. In those situations where you're applying nitrogen in season, the crop, you know, once it was planted, it was planted a little later.

If we remember back to February through March, April, we all thought that we were going to be planting early, and then it really got wet and delayed. But once we were able to get the crops planted, those locations, the crop looked fine. And, of course, we didn't have the issues with nitrogen loss, not because not because we lost nitrogen, it's more because we didn't apply nitrogen. So once we establish the crop and then apply nitrogen, things look fine again for those regions.

Brad Carlson:
Wetness, this year was a major factor in all this, but I think it's also worth noting that there were some strange conditions last fall during application season, and I can say that from firsthand experience on some of my own property. We've rent the land out, but there was an anhydrous application. It was just prior to the deer hunting season. You know, it had been pretty dry, but there was actually a shot of rainfall, and then the ground froze a little bit, but not deep enough that the application happened. And I know the application equipment slabbed the soil up really badly.

Just, again, I know this simply because we were out there deer hunting, like, 4 days after the application. I could smell ammonia all over the place. You know? All over the property, I could smell ammonia, and we just knew that it didn't it it didn't go where it was supposed to go. And so there are also some odd situations like that.

If that happened to me personally, I'm sure that I'm not the only place where that happened.

Fabian Fernandez:
You know, we talk about anhydrous ammonia or manure applications. Even if you're doing them at the right time when the temperatures are cooling down below 50. This, like you said, Brad, you know, this winter we didn't really have very cold days, there was not a lot of the soils didn't freeze that deep. That meant that they also warmed up pretty quickly, and so the process of nitrification that happens on nitrogen, any nitrogen, was well and alive much earlier in the spring and it ate longer in the fall. And so even if you looked at, applying nitrogen at 50 degrees when it's cooling down, the reality is that we had a pretty warm winter. And so the process of nitrification, you know, slowed down or stopped for a little bit, but it was definitely a lot shorter than typical.

That's definitely one of the challenges with nitrogen. And, of course, we are not saying anything about other sources of nitrogen. If you apply urea, well, forget it. You know that you'll be losing nitrogen even on a regular winter, fall, winter, spring from those fall applications. And this last winter, since it was so warm, that would have been even more of a problem.

Jeff Strock:
You know, with the really open conditions that we had over the course of the wintertime, the warm temperatures here in the southwest, we had about 6 inches of rain in October. And so as we went into spring, there was a, you know, a likelihood that we probably lost some of that nitrogen through volatilization or denitrification just because those surface soils were warm and wet to begin with.

Jack Wilcox:
Brad Carlson, some farmers understandably are saying they're not going to apply fall N anymore based on how 2024 played out. Is this warranted, or is it maybe a bit of an overreaction?

Brad Carlson:
We had a little conversation about this as a group before this, and I think we concluded it's both. It's both warranted and an overreaction. I mean, the data has shown for a long time that spring application is always as good as fall, almost always as good as fall. You're really just playing kind of a risk management game as far as whether the conditions become right

for nitrogen loss with fall application. And so while we look at in parts of the state where we do have fall application as part of our recommendations, you know, in general, the conditions are fine to put on nitrogen in the fall.

The closer you get that application time to the time the crop needs it, just the less risk you have simply by way of it's if it's not out there, it can't be lost. And so, you know, we look at some of the data, I know, like from Waseca that I've seen in the past that shows an average there being a higher yield for spring application than there is to fall application. However, if you really get down to it, what you find is in most of the years, there's no difference. And then in some of the years, there's a big difference. And so this was a year we found a big difference because of the way the weather conditions played out.

Moving forward, if farmers choose that, you know what, I just want to put it on in the spring and not worry about it, I don't have a problem with that. I think that's a fine management practice. You know, obviously, we know that the industry and the retailers looking at their applications have warned for a long time that they can't get all that nitrogen applied in the spring. I'm not so entirely sure about that as far as, you know, we've been doing that in southeast Minnesota for quite a very long time, not having fall applications, and it manages to get on. I do suggest that you have a conversation with your retailer and tell them that's your intent, to make sure that, when you know, if you call in February and say, oh, well, I didn't put any on this year like I usually do.

Now we need to get it on. You don't get pushback, relative to scheduling it.

Fabian Fernandez:
Brad, I think that that's a really good point that you make in terms of not having enough equipment or or or personnel to do the applications in the spring, but, the reality of it is that in years where we have had really wet falls, for instance, that hardly any nitrogen went on, We normally are able to apply all the nitrogen that we need the following year. So it is less convenient, but it is, I think, in most situations, it is possible to get it done. Looking kind of long term based on what we are seeing and what people that work in climate are telling us, with models looking at climate and what is going to happen, I think moving towards more of a spring application and not relying on a fall application may be the long term scenario that we'll be dealing with. I think, unfortunately, some of the things that they are predicting with climate models is to have more of these kinds of seasons more often, where we have wet springs followed by dry summers. And so moving an application to the spring is probably a good thing, you know?

Yes, right now we are not forced to doing that, but I think as a producer that is asking when they want to apply nitrogen, I think that that would definitely be a good move. And then for the industry also to be proactive and start to look at ways where they can figure ways to to move these applications towards the spring more than the fall. It's simply because if we do

see these things happening more often with wet springs, warmer winters, the potential for 90 to 12 months from a fall application, it's much bigger. It will continue to become bigger, I think, if, again, if we see these models coming to fruition in what we see year in year out.

Brad Carlson:
And I think it's also important to realize that the infrastructure that we're dealing with right now is different than it was a decade ago. The capacity to do split applications, you know, across a big part of the state is way more, than it used to be, as well as the presence of some of these large spin spreader, you know, the the, the, Rolgator type mounted spin spreaders that can cover lots and lots of acres really fast. Well, that didn't used to necessarily be the case. And so I do think, you know, obviously, if we're trying to apply, you know, broadacre anhydrous in the spring, it might be problematic. But as far as getting nitrogen applied, I I think we can do it.

Lindsay Pease:
You know, in northwest Minnesota, we have a very, very different system than the rest of the state of Minnesota and for sugar beets in particular, you know, lots of research have shown that that fall application is a lot better because you run the risk of damaging the sugar beet seed with too much nitrogen applied in in the spring, so I do think that that's one scenario where I don't necessarily see, you know, those, that fall versus spring application, you know, going anywhere, you know, that question coming, coming in because, I mean, I think it's a big question. I don't know that with all the crops we're gonna be able to go with a spring application. I mean, I also think the other thing for fall application, when you're dealing with the northwest, we have such a high volume of snow melt, and you're trying to get those crops in. You know, basically as soon as the soils are trafficable, you're planting. So I actually do think northwest Minnesota has kind of a little bit different system that, you know, we're gonna have to kind of see how some of these springs developed.

I don't necessarily see or recommend those fall applications going anywhere, though, just because of the specifics we're dealing with, in our region.

Brad Carlson:
It's worth noting, Lindsay, that we put together that advanced nitrogen smart session on dealing with climate, and we looked at some of the changes in climate across the state. And, actually, we didn't see that big of a change, in the valley. You know, basically from about Morris north, it looks fairly similar to what it has for the last 30 years. It's really kind of that southern half of the state that's changed most, dramatically, and so that's a very good point.

Fabian Fernandez:
And, Brad, you know, you mentioned the, some of the changes in technologies that we have to apply nitrogen, cover a lot of acres quickly. The other change that has happened is that there is less anhydrous ammonia available. And I don't want you to dwell too much on this because I think we have covered this topic to death already. The a lot of that anhydrous

ammonia has been taken up by urea, and that is a situation where for the, you know, lower 2 thirds of the state especially, fall application of urea is just not a good practice because the potential for loss from urea compared to anhydrous is much much higher. And so that's another thing to keep in mind.

In addition to some of the technologies that we have now to apply nitrogen quicker in the spring or as side dress applications.

Lindsay Pease:
Yeah. One thing I do see maybe shifting for northwest Minnesota is maybe that timing of that fall nitrogen application might need to be pushed back a little bit. I always feel like I'm saying on these podcasts, you know, for people to make sure they're watching the soil temperatures because, you know, we did not hit 50 degrees at all for our soil temperatures really until late October this year. So if you're going based on your traditional schedule, if you take the crop off in early October, you get your fertilizer out mid October, you know, those sorts of things, those traditional calendars aren't necessarily going to work. I mean, this fall and the previous fall we had 50-60 degree temperatures in November which is, you know, crazy for northwest Minnesota.

So your window for field work, I assume that's the positive side. The right side is the pot the window for that ball field work has been there, but, you know, I definitely don't wanna caution people against trying to get that out too soon because, you know, we do still have those loss issues. We just maybe don't have the window in the spring that helps us buffer, quite as much as in southern Minnesota.

Fabian Fernandez:
Yeah. And that's an interesting thing, Linds. When I moved to Minnesota, I was excited about having a winter so I would know how to do stuff outside and, you know, to have a break from the growing season. But this growing season and the time to be out in the field, it's getting longer and longer and longer. I remember when I started, in 2013, John Lamb, that was, faculty in the department, we were talking about drainage and, he's like, well, you know, from about middle of November until the end of March, you're not gonna see any drainage.

And, I have had winters here where, you know, around Christmas time, we are still collecting drainage water out of plots. And so things are definitely moving to warmer winters, and that for nitrogen, unfortunately, is not a good situation.

Jack Wilcox:
Jeff Vetsch, is there any data back from split application trials or evaluations of rescue treatments? And if yes, what did it tell us?

Jeff Vetsch:
Yeah. Actually, we had data on both of those. In Southeast Minnesota, we had 4 sites where we looked at split applied in versus and applied at planting or pre plant. And 2 of the 4 sites,

the split applications yielded better. And at 2 of those sites also, we use less N when we split applied compared to N applied at planting.

And I would also comment that at extraordinarily high yields at 3 of those 4 sites this year in Southeast Minnesota, 260 to 290 bushels per acre at, at 3 of the 4 sites. We also had some rescue studies that we initiated here at Waseca when we kinda saw what everyone was dealing with in early July with some very poor looking fields. We set out 2 sites. We applied the rescue N on July 12th when the corn was about V12. So it's probably later than we would typically expect you would do this.

But rescue N is a lot different than a planned sidedress application. You put your rescue N on when you know you need it, and you can get out there to do it. So we had 3 N rates. We had a check, and we had 40 pounds of N and 80 pounds of N. And at one of the sites, the 40 pound N treatment applied at V12 had a 12 bushel yield advantage compared to the untreated.

And the untreated had a total of 140 pounds of N per acre applied pre-plant, and it was a combination of N sources, anhydrous ammonia, ammonium sulfate, and some MAP in there as well. The other site had 40 pounds of N applied at that rescue time, gave a 8 bushel yield advantage compared to the untreated, and the 80 pound treatment gave a 15 bushel yield advantage. Haven't done the stats yet, so I'm not sure that's gonna be statistically significant for the 80 pound. But, certainly trending in the right way, and, economically, the cost of the fertilizer is less than that. So that site had 160 pounds of N applied, and it was all as pre-plant anhydrous ammonia.

One of the things that I think was really interesting about these two sites is they looked horrible in early July. They were uneven, short corn, one row good corn, the next row it was pale, it was nitrogen deficient. Very typical of what people saw all around this area.

But all the untreated checks still yielded right around 200 bushels to the acre without additional N. So those additional bushels I talked about were on top of that. So they still did quite well with that spring ammonia as the normal N source. And, yeah, we picked up some extra bushels, and it was economically the right decision, but it still did quite well. And I would have never guessed it as bad as those fields looked in late June, early July.

Fabian Fernandez:
What you mentioned, Jeff, in there, I think it's, something really important to bring up is the fact that we did have a lot of rain. The temperatures were a little cooler, but the reality is that once a crop was established and you had a good establishment, there was a lot of mineralization this year. I mean, we had plenty of rain to get a lot of nitrogen mineralized, and that covered a lot of the issues that we saw early on. You mentioned, you know, 200 bushels with no nitrogen. Well, right there is telling you that, that nitrogen is coming from somewhere.

I don't know if you're talking about 200 bushels with no additional nitrogen. Was that not additional nitrogen or nitrogen at all?

Jeff Vetsch:
Fabian, that was 200 bushels with the original N application, which was 140 at one site and 160 as anhydrous at the other site. So those original applications that looked bad in July still performed quite well, but we did pick up additional bushels, when we did a rescue treatment on top of that original application.

Fabian Fernandez:
And the reason I mentioned this about mineralization is that, you know, I saw some fields where late July, I [saw] nitrogen rate studies where we had a check with no nitrogen, and these were all spring pre plant applications. And we could only pick up the check plots, you know, the 60 to 80 pound nitrogen rate, the first rate of nitrogen that we apply, it looked just as green as anything else. And then by August, then you started to see some differences with those lower N rates. But up to that point, there was enough nitrogen again because we did have a lot of mineralization in these soils that if you had organic matter with the precipitation and good temperatures we had, it was a lot of nitrogen being produced through that process. So it would have been, I think, more devastating this growing season if we would have had drier conditions early in the summer.

Jeff Vetsch:
Yeah. I would agree with that. One of our southeast Minnesota sites, near Dover, which is pretty close to Saint Charles on I-90, That site was corn after sweet corn, and it had a oat cover crop with radish in it, of course, which froze out in the winter. And it yielded almost 200 bushels with no nitrogen, and it did 280 with 120 pounds of N. So that was pretty impressive.

Jack Wilcox:
In hindsight, what would have been the ideal practice to have used this past year?

Fabian Fernandez:
Well, you know, I think we touched on some of these things already. I think having a spring application would have been a good practice, and I would probably look into doing a split application where I maybe apply a little bit of my nitrogen early on before planting and then split apply. Again, not in every situation we saw a need to do the split application. If you did a spring application, especially with anhydrous that takes a little bit longer to nitrify, I think you could have been okay. But, this is a year where those split applications tend to perform better when you have really wet conditions early on.

You know, looking back at this season and looking at all the uneven unevenness that we had in the fields, that unevenness was pretty much all related to drainage. The areas of the field that were low where you had, you tend to accumulate more water and stays wetter longer, those are the situations where the crop looked the worst. Looking back as, you know, maybe

managing crops differently, and this is one of the the potentials where I see precision ag maybe having a a good benefit, a good impact is in managing parts of the field that tend to have these issues differently. You know, we are doing research looking at a controlled release urea, for instance, as a way to apply nitrogen in those areas where you have more potential for nitrogen loss. Obviously, polyamide, urea is more expensive than urea, but, if you can apply only in those areas where you have more potential for water accumulation and denitrification, a lot of that nitrogen gets lost through denitrification in those low lying areas.

That's where I could see some of the benefits. In terms of nitrogen rate, I would say that, again, hindsight, and I haven't seen a lot of my data yet. I haven't calculated all the economic optimums yet for the data that we are collecting, but, I would say that we were probably, if you're applying the economic optimum that we recommend, you would have been about right. Because, again, we did lose quite a bit of nitrogen, but there was a lot of mineralization to cover up some of that. And so, from what I've seen, I would say that probably applying a rate around the economic optimum is what I would, again, do based on those conditions.

Jack Wilcox:
Moving forward, what can we take away from the 2024 growing season with respect to how to manage fertilizer?

Jeff Strock:
In addition to, you know, no replacement, no good replacement for just managing our nitrogen fertilizers really well, in our part of the world in Minnesota, there's obviously a need to have adequate subsurface drainage for our crops. And so there might be some people out there who may have found where their tile might be a little bit too far apart and that, that might be something helpful for them to to think about. But, you know, we also hit on nitrogen rates. And the fact that even though we had a pretty wet year, especially early on, we had uneven corn. We had some low drowned out spots, where where things didn't look good, for quite a bit of the season that because of the fact that the the conditions were such that we had adequate mineralization, making those decisions for the maximum return to nitrogen or MRTN recommendations were were really probably hitting the head, or hitting the nail on the head.

And as far as timing, I think one of the things that you've heard from the group is that, you know, we know that, in most years, there's not gonna be a lot of difference between fall and spring applications of nitrogen. When we do see these differences, the big differences show up where that spring applied and really outperforms, the fall applied. And so I think there's some really nice threads of message that we kinda can see from today's discussion. The other thing, though, you know, when we think about moving forward as well and and and, Brad and Ryan were just over here in Lamberton. We were doing some recording, of some things.

And I know I've had a little bit of a conversation regarding N losses with Jeff Vetsch and thinking about some of the N loss that we experienced this year. You know, one of the things that we need to remember is that, you know, with the fact that we came out of 3 years of drought, and we had really wet conditions, and we had conditions that were warm over the winter, warmed up quick in the spring. A lot of nitrogen was lost before any spring-applied nitrogen was put on, and it wasn't necessarily the fall-applied N that leached out. There was likely some residual and carryover, from these last 3 years that may have come out of the profile. So when we start thinking about those things, it's all always, you know, an awful thing for the farmers to have applied nitrogen that, you know, because of mother nature, they have no control over trying to save it.

But, you know, we do have a lot of practices out there. You know, we've got bioreactors and saturated buffers, things like cover crops, you know, in the entire field. There are practices out there that, you know, if we do start, you know, seeing some of these losses, there are some things out there that we can do to, to try to help mitigate some of those, those issues, because it's not only just the loss to the farmers, but it's some of that loss through the pipe and down into the waterways and and further on downstream that can cause some negative impacts. So, you know, just having farmers be aware of those things and, you know, being really tuned into, I think as Brad started out talking about initially, some of the advanced nitrogen smart, lessons learned about some of these types of practices can really help mitigate some of those, those, unexpected and unintentional losses, of nitrogen in terms of how we kinda try to think about managing those systems, not just the fertilizer and the timing source rate things, but also, you know, what do we do about it after it leaves the field.

Brad Carlson:
I think one of the things that we keep stressing with NitrogenSmart is the fact that the system is pragmatic. And when things don't perform the way we want them to or you needed more or you needed to do something different, those reasons are knowable. And particularly, extreme climatic conditions are some of the things that causes that to happen. And I know we've moved with some of our fertilizer recommendations. Dan's been very instrumental with, for instance, phosphorus and potassium, looking at what the probability is of response at, for instance, various soil test levels, and then applying fertilizer anyway.

You know, I think we also need to think about some of these situations on a probability basis being how often does this happen. If you're making a major management change because something happened once in 20 years, that's probably not a really good decision to make. Now, you know, given what Fabian was talking about earlier, if we see some major shifts in the climate and this stuff starts happening more and more often, then absolutely some changes are warranted. But, you know, at this point, I don't I don't know anybody I've talked to that can compare what happened this last year to any previous year. There was some localized stuff like that in 2016, I know, but not nearly as widespread as it was, this past year.

I guess only time's gonna tell us if this sets itself up more frequently.

Lindsay Pease:
I think something for everybody to keep in mind is the weather is always something that is going to be unpredictable. Right? If we could predict we have weather predictions, but we are always dealing with this guessing game of what the next season is gonna be. And I think even though we're kind of talking about, well, how would you, in hindsight, strategize, you just kinda have to do the best you can. I think when we're starting to look at even nitrogen management strategies and then thinking about, you know, reducing nitrogen loss to the environment.

It's always kind of you're just kinda taking your best guess, and so we know there's always a percentage of loss that's going to happen. And I think that's where that economic return on nitrogen comes in. You know, that's protecting you as a grower from some of those environmental changes. But then also, you know, when we know there's gonna be loss happening, that's when you can start to apply other strategies. But like Jeff was mentioning, things like control drainage, things like, you know, maybe cover crops, things like a bioreactor to help prevent if you're in a system that is really prone to that excess loss.

Fabian Fernandez:
I haven't looked completely yet at all the data from the study that we have in Lamberton, but I can tell you that in terms of just drainage, I don't know how much nitrate total loss was. But in terms of drainage, this spring, we had more drainage than the last 3 years combined. I think this is important in terms of nitrogen loss and the environment that we cannot just say, well, you know, it's the farmers are not managing nitrogen incorrectly and look at this mess, is that mother nature throws some of these things, that are extremely difficult to deal with. We came from 2, 3 years of fairly low precipitation, but a bit of residual in that accumulated over time, and then you get all this precipitation coming in before the plants can even use any of that nitrogen plus, whatever. It gets mineralized in between, and then you lose it.

And so it's a very simplistic approach to say, well, it's all related to farmers applying too much nitrogen. It is not as simple as that. There are a lot of complicating factors there. And like Lindsay was saying, one of the challenges is knowing what's going to be during the growing season. I mean, this year, even, if you saw that really wet conditions early on and you say, well, I'll keep applying nitrogen later and later in the season, I would say if you waited too long to apply nitrogen, that was also a problem because the crop only had a fairly short window of time to get nitrogen that we apply there to use it before then it started to get really dry.

So, you know, I mean, you look at the cobs, they all look really nice. They filled up nicely. All the kernels were fertilized, but they didn't fill completely, you know. The kernels are kind of shrinking there. They have room between the kernels, that's telling me right there that the plants run out of water to completely fill that grain.

And so I suspect that these wastes are going to be low in a lot of places. And there is absolutely nothing you can do from a nitrogen application timing standpoint to fix that. It's like you, at some point, you just have to say, okay, this is when I need to apply my nitrogen, and you still have a fairly long time between that time of application to the time that all of that nitrogen will be used by the crop. That weather can do any sort of things. And in this year, with the dry conditions later on, you know, you had the nitrogen in place, but then there was no water later on for the plant to take advantage of that nitrogen.

And so it is always a challenge. And so looking again, I think at probabilities is where we have the best safety. It's like on a 10 year frame, how often do you see something happening? And I think Jeff, Strock mentioned the fact that fall applications, for instance, they can perform very well, but the years where they don't perform well, they perform really bad. And so it's like I have never seen a fall application doing better than a spring application.

They do just as well or worse than a spring application. So that to me is telling me that if I had to bet on the probabilities, I would say, well, if I can, I will try to move my application to more of a spring application because at least I have that security that, I will be right more often than not?

Jack Wilcox:
Are there any last words in the group?

Jeff Vetsch:
You know, one of the things I would say as a final thought was that it was agronomically the right idea to use split application this year, but logistically, it was challenging. There were not a lot of days in south-central Minnesota in June to put on supplemental or sidedress in because the fields were just too wet, and you probably prioritize herbicide applications before anything. So that is the caveat to one of these years that, you know, if everyone goes to sidedress or split applications, you might have some years where you have a lot of nervous nights because you don't get out there to put it on.

Jack Wilcox:
Fabian Fernandez in Saint Paul, Jeff Vetch in Waseca, Jeff Strock in Lamberton, Lindsay Pease in Crookston, and Brad Carlson in Mankato. Thank you all for joining us today.

Jeff Strock:
Thanks a lot.

Lindsay Pease:
Thanks everybody.

Jack Wilcox:
Before we go, if you have a question or comment for one of our guests, or a topic you'd like to hear discussed in an upcoming episode, please email us at nutmgmt@umn.edu. Thank you, and we look forward to hearing from you.

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

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