Of Jellyfish and Auxotroph

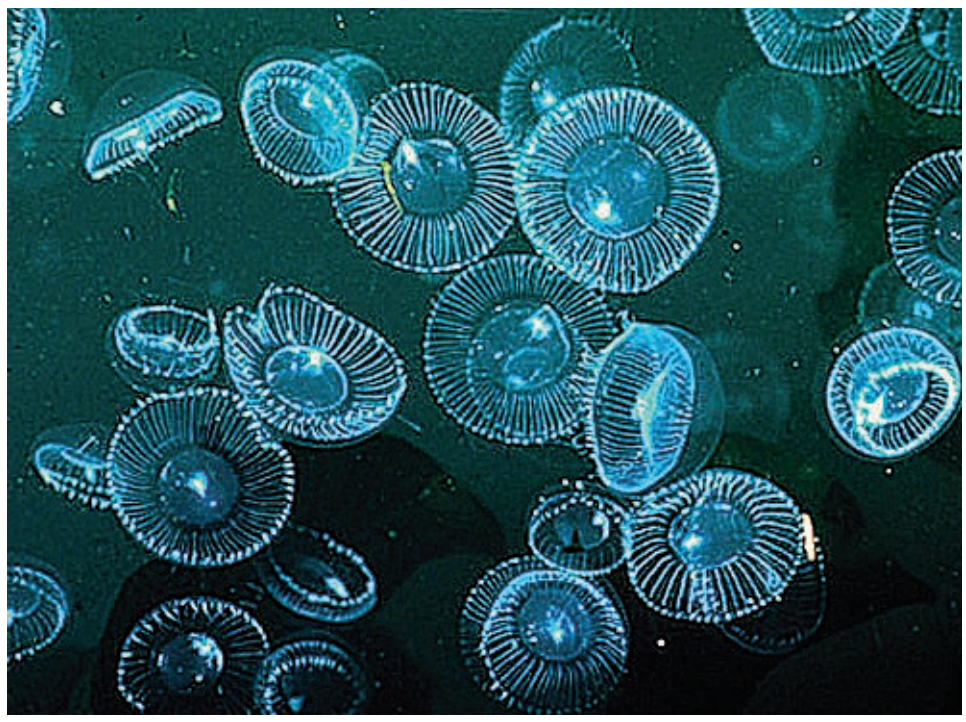
Groundbreaking new test for nitrogen is a real game-changer for farmers

BY TIM KALINOWSKI

The operational philosophy of farmers in western Canada the last few decades has typically been fertilize, fertilize and, when in doubt, fertilize some more. Not only has this mode of operation been very expensive for farmers, it has also very often led to secondary contamination in local area water tables from run-off of excessive fertilizer. On occasion, without moisture to make the chemical fertilizer used soluble, too much fertilizer has even led to chemically burnt crops. Part of the reason why local farmers struggle with the right balance in this respect is a lack of specific information about how much nitrate is getting into their plants at a given cycle in the year, and because the soluble nature of these nitrates often leads to progressive nitrate loss in fields as the nitrate becomes diluted or washes away. There are several tests for nitrogen out there in the agriculture but these are notoriously unreliable and often quite expensive. Nitrogen levels in the plants and the soil also continuously change throughout the year; so even if you get a test done in the spring this is no indicator of how much nitrogen you'll have available in your field by mid-summer. So many farmers often forego any testing at all, and stick to the philosophy that overkill is better than underkill when it comes to applying fertilizer.

But what if we could tell you that there is a new test for nitrogen currently under development that costs only $1.00 per sample, and it is many times more accurate than any other nitrogen test out there right now? We're sure many farmers would think that this, surely, must be the stuff of science fiction.

And what if we were to tell you that the key ingredients which make this test so accurate are a strain of nitrogen-loving bacteria crossed with the DNA of a Jellyfish? We're sure at this point most farmers out there would think that only the Advance has the courage to tell real whoppers like this anymore; and they would probably be having a real knee-slapping laugh at our expense.



Phosphorescent fantastic! Added Jellyfish DNA is the key to making his agriculture nitrogen test about "ten thousand times" more accurate according to bio-researcher Dr. Manish Raizada.

And then what if we told you this bacteria/ Jellyfish DNA additive actually glowed brighter, phosphoresced, depending on how much bio-available nitrate was available for plant-use in a given laboratory sample? We're sure that farmers would be saying "Call the funny-farm! That Gull Lake Advance has finally gone all the way loopy. Someone has to put a stop to it!"

But, on the other hand, what if it all were true? We recently had the privilege to interview one of Canada's foremost plant and bio-science researchers in the person of Dr. Manish Raizada of the University of Guelph's Department of Plant Agriculture. For the last five years Dr. Raizada has been working on trying to come up with a test for nitrogen which would be both highly accurate and highly affordable. He was thinking of farmers overseas in developing countries, and their meagre budget for such tests, when he began to conceptualize in theory what has turned into a wondrous reality when the first applied tests for this technology completed last year exceeded all Dr. Razaida's greatest hopes and expectations. We asked Dr. Raizada if he could explain the theory behind the technology for our readers.

"What we did is took a gene from jellyfish, which live in the deep sea and glow in the dark … So we took the gene that allows it to glow in the dark and we inserted it into bacteria. But we inserted it into a special strain of bacteria: that strain of bacteria only grows when it has a certain type of nitrogen in its environment. The general name for that kind of bacterial strain is an 'auxotroph.'

"Essentially we take the gene from the jellyfish and put it in this strain of bacteria, and only when this specific type of nitrogen is in its environment will the bacteria start to replicate, and as it starts to replicate it will give off light as a jellyfish would."

Whoa! Run that by us again. The bacteria will actually glow as it replicates in the presence of a specific type of nitrogen?

"Yes, the reason we are using this jel-

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lyfish gene is because of the light. We could just measure the amount of this strain of bacteria, so if this nitrogen is around this bacteria strain will grow, but in seeing this "light" gene, and measuring the amount of photons emitted, it makes this test probably more sensitive by ten thousand fold. It is the combination of the jellyfish DNA and the bacteria that make it so sensitive."

So let's get this straight. The bacteria will actually glow so we can see it, and glow brighter the more of this nitrate is available in the sample?

"That's a good question (laughs). No, this test has to be so so sensitive, so subtle, that we can't actually see it with our naked eye. Some insects could probably see it, but we can't."

So we are not going to be faced with glowing lab samples if we turn out the lights, which is sort of a relief actually. Then how do we "see" this glow then?

"We use a special camera that can detect a small number of photons, and what it does is magnify that (light) signal on a special chip and converts it on a computer screen into something we can see."

Okay, Doc, now hit us with it; we can take it. How does this help a farmer in Saskatchewan to know precisely how much available nitrate is in their soil and crops?

"The current test for nitrogen is essentially the total amount of nitrates, let's say, in the soil; sometimes the total nitrogen. But what you really care about (in agriculture) is how much nitrogen is available for the plant to take up. Because, ultimately, a lot of nitrogen, even nitrates, is in forms that plants can't use. So take total nitrogen; a lot of the form is taken up in organic matter. In the case of nitrate, some of it is available, but it depends on soil type. So, for example, if soil is heavy in clay then some of that nitrate is not actually available to the plant. So what you care about as a farmer is what's termed "bio-available" nitrate. The advantage of our auxotroph (jellyfish) bacteria is that it mimics the root system of a plant in some ways — so if it can get it so can the plants."

Uhhh …. Can you be a bit more specific?

"In the North American context, in the Canadian context, farmers, if anything, add too much nitrogen because it's an insurance policy. And where it tends to be critical is that farmers will add on nitrogen before planting, they'll top-dress, etc., but what they really want to know is should they top-up nitrogen after planting? So should they side-dress afterwards? And often farmers will, and they'll do it just as an insurance policy, without any data to back it up. And that's probably where they are wasting nitrogen, and that's where they are doing environmental damage, and that is where it is costly.


Dr. Manish Raizada

"So one of the tests we are developing right now is where we take leaf-punches from a plant, and a farmer can do this, just take a handful of leaf punches — the farmer freezes those leaf-punches and he sends it to a lab, we are a few years away from commercialization so in this case us, and then we analyze them. We take those samples and we mix them with our special bio-sensor bacteria, and we look to see exactly how much nitrogen has been taken up by the corn plant, wheat plant, etc., and it's an indicator, in this case of, well, do we need to add more nitrogen or not to the soil? Or is it already sufficient in the plant?"

Sounds almost too simple. But what makes this any different than any other nitrogen test out there in the market now?

"We have compared our test to other commercial technologies out there that are claiming to do this job, and those technologies could not do the job…This is an actual blind test we did on a trial farm here in Ontario and, quantitatively, they could not (when tested) distinguish a background of 35 lbs of nitrogen per acre versus 80 lbs per acre versus 135 — whereas our technology could distinguish those three groups, and we're really excited about that! That's really promising. It could, potentially, save a western grain producer thousands of dollars if this works in the commercial market in a couple of years."

Thousands of dollars! Now you're speaking my language. And you say when it becomes commercially available, in two years or so, it should only cost $1.00 per sample to do these highly accurate nitrogen tests?

"Yes, the price point of our technology will be about $1.00 per sample and other tests for nitrogen out there are about $10.00 per sample. So that's a big advantage… This means that a farmer could easily test one hundred times for a fairly inexpensive cost and that would give them better resolution of their field, and they could also sample multiple times during the season to try to figure out what's going on. Because nitrogen is so soluble in soil you need to look at multiple data points, and that's sort of difficult for farmers to do right now.

"The other reason I'd like to see a dollar per test price is because that's the economy of scale for poor farmers in developing countries; so anything I do (research/ invention) I say let's make sure it's not more than a dollar—in fact we even want to get closer to $0.10, and we'll work toward that in five years."

In all seriousness, we at the Advance really enjoyed our conversation with Dr. Raizada, and he is remarkably easy to understand for being a research scientist of his calibre. We also enjoyed hearing from Dr. Raizada about how much he cares about the plight of farmers around the world, and how he has personally made extraordinary efforts to put together very affordable kits with specially treated seeds, pictorial agriculture guides to help illiterate farm women in developing countries understand how to use these new technologies, and improved hand tools to help ease some of the burden of farming for these women. Dr. Raizada hopes that his auxotroph bacteria, and the other, even more advanced, experiments he is working on, will help farmers all over the world to grow better crops, and to make these advanced bio-technologies as farmer-friendly as possible. The auxotroph bacteria, with jellyfish DNA, has, in Dr. Raizada's opinion, an enormous potential to be re-engineered in the future to also help producers measure other potential deficiencies in their plants like shortages in minerals such as potassium, zinc, iron, boron and other important micro-nutrients. But his most immediate desire is to get his current nitrogen test to market as soon as possible, and to move ahead with developing a viable and easy on-farm test using this technology in the next five years.

"My dream, and it's not going to happen for at least five years, is to have an on-farm test where farmers can do it in real time without having to send it away to a lab. This will empower them so they can see 'well, this part of my field is not doing so well, and this part is doing well.' Long-term, of course, we need to attach it to some precision farm equipment — that's where we need to go … The commercialization of this technology depends on things like engineering, and a number of other factors that go into making a commercial product - funding, etc. We're still at the pilot phase of this. I'd say a realistic, commercial, on-farm test will be 2-5 years away…and I think that's realistic."