

Nutrient Management, Variety Trials, and Pest Control in Potatoes—Bridging the Gap Between Conventional and Organic Agriculture

Dr. Robert Coffin

All of us have to work together to try to make it a better system and practice sustainable agriculture. I'm going to raise some issues this afternoon to make you think; that's the purpose of a presentation—to make you think. I'm probably going to use pretty close to the 20 minutes. We're going to talk about nutrient management, manure, and fertilizer trials. We're going to talk about potato breeding, some of their major diseases and pests, and making informed decisions on organic, traditional, and genetically-modified organisms.

Nutrient management is very important, but before I get into that someone has to put in a good word for potatoes. I hear it on the TV—the people say potatoes are just empty carbs, and that just boils my blood. The truth is potatoes contain carbohydrates, vitamins, minerals, and protein. They are a very good food. We've got to put in a good word for potatoes.

Now we'll go on to the other situation. Potatoes originated in South America; quite a diversity of genetics. The potatoes capture energy from the sun. They take that energy and turn it into tubers loaded with carbohydrates. There's your starch granules inside of a potato cell. About 80% of the potato is water, 20% is dry matter, and we have a range of different nutrient families in potatoes. So from a chemist's point of view, this potato has some water, some starch, and some vitamins, minerals, and protein. That's it in simplicity.

You're going to get a real whirlwind course in nutrient management for the soil. We have to feed our crops. If we're going to have good yields, as Yves already said, we have to feed our crops right. You have to understand the recycling of nutrients because we're all involved in recycling nutrients and you're all part of this. I'm going to show you here in a few minutes. Human activity recycles nutrients, Mother Nature recycles nutrients, but our objective is to give the crops an optimum nutrient supply without causing problems in other situations such as well water. When you turn on your tap in some places in PEI, there are higher than internationally accepted amounts of nitrates in the water, and it's a serious issue. So we have to address this. We're all part of it. Even our premier has written articles saying he's concerned about high nitrates in some parts of PEI. He's right.

Management practices for potato crops is an issue confronting all of us no matter which way we go. Potatoes require more nutrients or fertilizers than other crops. Potatoes have a wide range of pests, hence the widespread use of pesticides, and we require careful land management to avoid soil erosion and nutrient loading.

A quickie course in the history of PEI potatoes: When the first settlers came to PEI it was covered with woods. They cut most of the trees down, and there's hardly a white pine tree left in PEI today. Our soil was generally acidic, low in natural fertility, but very responsive to fertilization and management. Back in 1900 if you had a horse-drawn planter you were in the big league. Now you can sock in fertilizer and potatoes at quite a pace. There are many people today who have never lifted a bag of fertilizer or potatoes—you just pull a hydraulic lever. Everything is mechanized, so no wonder they get big acreage. Here is spraying in 1920. In 2003 you turn on the air conditioner and your favourite stereo station and away you go. It's a different world. Now, despite 100 years of growing potatoes on PEI, the yields have really only increased about 2 ½-fold—not that much. That's the truth.

Movement of soil and nutrients occurs by water, wind, and human activity. It is an unfortunate situation to see sloping fields. We see this in PEI—erosion, soil in the ditch going across here, also livestock operations putting manure and nutrients into the streams. We have to try to improve on this. Snow is supposed to be white, not brown. This is what you call “snirt”—a mixture of snow and dirt. It’s not snow. People were mad this winter when they saw that on their windowsills. But there are some good things. The province put in compulsory buffer zones to keep the farmers from going up to the edge of the streams, especially for potatoes. Watch this guy stop right at 20 meters. He’s going to slam on his brakes because he knows he’ll be in trouble with the law if he carries out his farming practices within 20 meters of a stream. This is starting to happen; there are some better practices starting to come into play. Some of our better growers are spreading hay and straw, and some of them are planting cereal crops after early crops of potatoes. All of these are good things. But in your potato belt you have huge acreage of potatoes in limited areas, and that does cause quite a bit of pressure. Some of these fields should really be used for ski hills—really. What happens when we get a heavy rain here? The soil turns brown. Without a doubt, the red water contains nutrients and possibly pesticides. That’s unacceptable. Do you know what happens? Lakes and streams should be blue. If you get all sorts of nutrients running off, they’re going to turn green with algae and it leads to eutrophication. This is a challenge for everyone to cure. We had fish kills a couple of years ago. This is a very serious situation, and it affects all of us. So we must do everything possible to minimize these types of things.

What can the grower do? He can control the amount of fertilizer, he can control the soil and crop management, and also how he approaches pest management. What can the grower not control? The weather. Some falls this is what happens. We had this in 1998 and 1999. Would you like to be a potato beside that sprayer row? If you’re held underwater for a few hours you’re going to be dead—clinically dead. Potatoes can drown just like us. There is a lot of financial stress for those who are growing potatoes, and for those who help to support them and are linked with them there is a lot of financial stress too.

How do you make a profit growing potatoes? You have to get high pay yields per acre, as Yves has said. We have to find markets to obtain acceptable prices, and we have to have top quality, both for fresh and processing. In the fresh business they want potatoes with pretty faces. They don’t want *Rhizoctonia* on the potato, as it was said this morning. These are challenges facing all of us. Some growers have unrealistic yield expectations. They overfertilize, and they’re aiming for the 500 cwt/acre. Washington has a growing season of 400 days. Think about that. Do you believe me? They’re mowing their lawns down there now, and they’re planting potatoes. So they can get 500 cwt with no trouble.

Here is a simple explanation of nutrient management. There are 16 essential nutrients; 3 of them are carbon (C), hydrogen (H), and oxygen (O). They come from the air and the water. Those are the big 3; also Nitrogen (N), phosphorus (P), and potash (K_2CO_3). N has been difficult to quantify in soil tests. P is easy to quantify, but its availability is uncertain because sometimes it’s in the soil but the potatoes can’t get it out. So the soil tests keep going higher and higher and some varieties of potatoes just can’t take it out. Potassium (K) is generally easy to quantify, it is quite available, and some plants will actually do luxury consumption—they’ll take it up in very high amounts. Now watch as this plant grows. What’s happening to your nutrients? They are getting less. If I take that plant away, I’m taking some of the nutrients away. Sometimes we don’t even get a chance to take that plant away because there are other people or other organisms right there. You’ve all seen what other organisms can do.

Let me show you some of our plots here. These are our check plots. We do all sorts of trials testing new insecticides in the check plots. There's nothing left after a certain period of time. So they've taken nutrients and moved them away. We did a lot of trials with the plastic beetle trenches, and we had some success. We did some learning. This little cartoon didn't work for us here. You have a plastic-lined trench, and the beetles fall into it. Generally they can't get out, but we had some troubles. You must get the right angle on the sides of the plastic-lined trench. If you have spruce or fir trees along your hedgerow they will exude gum. The gum fell on the edges and it just made perfect traction. The beetles went right out. We didn't see that in all the good literature. I'm just telling you that the plastic-lined trenches will work, but make sure you get the right angle, don't have any folds in it, and don't put them along a hedgerow with spruce or fir trees, or the gum will give some traction there.

Let's get back to our nutrition course. You have to understand what the potatoes require. They require nutrients in the right amounts. Some, such as N, are required in large amounts; calcium (Ca) in medium amounts; and zinc (Zn) or copper (Cu) in very small amounts, but they're essential. This is a very important part of your nutrient management course. Anything that leaves the farm gate is a drain on that land. You ship potatoes, cows, pigs; they leave the farm. If you keep taking it off and don't return it, you're going to deplete the land or farm it out or it's going to be mined out, and your yields are going to go down unless you replace the nutrients that you removed. Where are those nutrients going? I'm going to tell you the whole story because you people are all part of this whole nutrient management thing whether you like it or not. Canadians are very well-fed people—excellent food, cheap prices. Where does it go after here, ladies and gentlemen? Well, think. A few years ago it was outhouses. There's a deluxe model. But now take a look at some of your larger cities in Canada. The city of Halifax pumps all of its raw sewage right into the harbour. It's quite a site to see if the tide is going the right way. It didn't go back to the farm. Now, we can bring chemical fertilizers back. A common fertilizer on PEI is 13-20-20. Organic growers could bring rock phosphate and some other materials back. You're replacing what you took out. You're putting it back in. Does anyone here know what "night soil" is? Human waste. Many people don't know that, but it's part of the nutritional package. If you go to India and China and places like that, there are people whose full-time job it is to take the human waste and carry it out and put it on the fields. Now that's a real severe type of organic. I talked to your coordinator here today, and she said she's not quite ready to go that route.

People are entitled to different points of view. Regulatory people are concerned about high nitrates in the wells. The consumers are saying they want clean air, clean water, and they want high-quality cheap food. Growers say they just want to earn a living. Within the grower group there are going to be differences of opinion. Some will say that they're interested in nutrient management, some are cautiously interested, and others say they couldn't care less—they're not interested. So this is the challenge that's confronting us. We have to reach a compromise through education and research. We do all sorts of trials, and other people are doing research and sharing it, which is very good. There are potato varieties that do require less fertilizer. In Europe we're seeing a preview. There are some very rigid regulations that limit the amount of fertilizer that can be applied to farmland. There are even places in Quebec where you can't spread manure if the soil P is high. There are manure brokers in Europe who actually try to find a home for the manure, and they may have to ship it 50 or 60 miles away just to find a place for it rather than spreading it in the pasture right on your own farm. We're still at the voluntary stage. We don't want to see compulsory compliance. Some people feel that there are too many regulations, but if we don't...The clock is ticking...

These are some of the trials we do. Those are nonfertilized plots. These ones are manure and fertilizer. You get some terrific growth, but sometimes you can get too much growth, and big fancy tops don't always pay the bills. It's what's underneath—the size and distribution. Overfertilization can become a liability. We bring the growers in and show them what we're doing. We realize that it takes time. It's not always a straight and simple path to resolve these issues. Only 5% of the people in North America are growing the food for the other 95%. A lot of people don't know where the food is coming from, so many of us have to work together.

Now in the next few minutes I'm going to share some more information from our trials. We did a lot of work on the effect of manure and rates of N on the yield and processing quality of Shepody and Russet Burbank potatoes. The amount of N that's being applied to farmland in PEI is becoming a serious issue, especially with regard to groundwater. If you put too much N on your potatoes it will move down through the soil. It gets in the groundwater and, under certain conditions, it's going to come up and come out your tap. If it's above 10 ppm (parts per million), then you've exceeded the international standards. This is a challenge for everyone to try to address. There's a lot of N in clover plowdowns, and there's a lot of N in manure. We did small-plot trials with cattle manure for several years, and the question is to know the quantity of nutrients that are in that manure and when they're going to become available. That's the critical issue. We've also looked at pelletized formations of chicken manure, and we're continuing to do that research. In our trials, we spread the manure at a rate of 28 tonnes/acre, we had fields with no manure, and then we had different fertilizer treatments and chemical fertilizers. We used 0-18-18 that has no N and a lot of P and potash, and 5-18-18, which has more N. We were able to see what happens when we superimpose these two treatments. When you had no fertilizer whatsoever on Shepody this was your yield, only about 75 or 80 ctw/acre. With 0-18-18 it went up a little bit, but you're really starved for N here. As we started to apply N, keeping the P and potash constant, the yields started to go up. Anywhere the manure went on, your yields pretty well went up. But your most dramatic improvements were right here—you actually doubled your yield. Do you see that everyone? Can everyone see that, conceptually? You double your yield when you put on manure, even with a 0-18-18 you pretty well double your yield. So the crop was starving for N, and the manure helped out in that situation. We'll just do it for the other variety very quickly. It's the same thing; we saw the same pattern. We had very low yields with nothing, but anywhere manure went on, up went your yield. So the benefits of manure are threefold at least—as a source of nutrients, increased microbial activity, and increased water-holding capacity. You can't really nail it down to one thing.

I'm going to talk briefly about some potato diseases. There are lots of diseases in potatoes. I'm going to talk about viruses and also about late blight. There's what potato virus Y (PVY) does to plants. There are healthy Russet Burbanks in the background. Here's a healthy Russet Burbank, and its neighbours on either side have leaf roll virus (PLRV). The yields from the healthy plants are much larger. Leaf roll-infected plants really hurt the yield. Another secondary loss is net necrosis; we don't have any market for zebra-coloured french fries—and also potato chips too. If you try to make potato chips out of a potato infected with net necrosis, it's not a very pretty-looking specimen.

There are a lot of debates going on between biotech and conventional agriculture, and as I said, I've taught a couple of courses, and we discussed this with the students. It's important to try to understand it in making an informed decisions because some people get pretty excited, especially in Europe where there are lots of debates going on. We hear the press every once in a while talking about it, and you can pick up magazine articles. There have been a lot of articles

written. We did all sorts of trials with genetically modified potatoes. These are Russet Burbanks after 5 years of severe virus pressure; here are your genetically modified Russet Burbanks, and here are your regular Russet Burbanks with 100% PVY and 100% leaf roll. You'd have to dig an awfully long row to get a few potatoes for your supper. There's a dramatic difference. They have stable traits, they work very well, and no things we saw hurt french fry quality or taste or texture. There is a similarity with the beetle-resistant Russet Burbanks that have the Bt factor in them—excellent stable resistance to Colorado potato beetles. The beetles just demolish the regular ones. All that happened is the you took some genes from the Bt bacteria that people are allowed to spray and put that genetic information in the potato plant, and it makes the same protein that adversely affects the Colorado potato beetles.

In variety screening trials you can have regular varieties or genetically modified potatoes, and what you're looking for is the weakest link in the chain, whether it's yield or disease resistance or processing quality or storage or maturity. Many people have a say in that—growers, plant breeders, biotechnologists, consumers, processing companies, and the media, who is always ready to get involved. Everyone makes the decision if the new variety is going to fly or not. If you take a look at the average number of pesticide applications to a PEI potato field, there are quite a few— between 10 and 20, with 15 applications as sort of an average. Most of that is fungicides and a few insecticides. If we could get late blight resistant potatoes, we could cut that number way down.

Let's take a look at the aphids that are responsible for spreading diseases. The traditional way is to spray the aphids. You can kill them with certain materials; the newest way is to put systemic insecticides in the ground. It goes up, the aphids come along and feed on the plant, and that's their last feed. This works, but another thing that is also very important is crop scouting. It's very, very important to have scouts walk the fields once a week, checking for the number and type of pests and beneficial insects and make informed decisions on pest control. Sometimes you have natural predators. This was already talked about by Christine Noronha. Sometimes you have some high populations of desirable insects, and they may be able to keep your pests below a threshold level. Sometimes farmers will bring a larval stage in to us. They don't know what it is, and they'll ask me, "What can we spray to get rid of these?", and I say, "No! No! Those are good guys!"

Perceptions and facts: I've heard some people say that all synthetic pesticides are dangerous and all organic pesticides are safe. This needs to be discussed—from a chemist's point of view, from a consumer's point of view, and the response by the plant. CuSO_4 has been used to prevent or suppress late blight for years. In Europe it may be removed from use. The Cu ion itself is a biocide; it will kill many types of organisms, and at high rates it will even kill the potato plants. Some pyrethrum insecticides or rotenone used by some organic growers can kill fish. So they do take some other living organisms out. High rates of bluestone on potatoes can kill your potato crop; it'll work as a topkill at high rates. We're going on a mushroom hunting expedition this afternoon. We're going to eat everything we gather, and you've got to trust me. Is everyone coming? It might be our last expedition. I think I drove the point home. It's all natural, but if we don't know what we're doing...Also, some potato varieties had their licenses revoked years ago because they had high levels of glycoalkaloids, even though they had fairly good resistance to insects. It was a serious situation.

Late blight is one of the most serious diseases of potatoes. There are very few resistant varieties on the market today. Without fungicides there wouldn't be any potato crop in a bad

year. It's a communicable disease; this has already been mentioned. Several hundred thousand spores a day are produced. They blow in the wind for miles. They'll move down into the tubers under the right conditions. This is what you end up with, and we can't sell potatoes that look like this.

There are challenges for the future in late blight. The late blight organism is undergoing evolution. There are many changes as we talk, and there are people who are concerned about all the spraying, and the potato breeders—either conventional or GMO—are making some progress. Until a few years ago there was only one strain. That was produced by asexual reproduction, and there are several mating strains now that permit new types to be formed. I'll just give you a little lesson on the birds and the bees. In the past it was A1 to A1 to A1 asexual propagation. Now there's some romance involved. Different strains of late blight are having dates. There's a little bit of romance when those A1s and A2s get together, and there is exchange of genetic information. We don't know what the stork is going to bring. There are a couple of strains recognized and, as I said, there are new types coming. This maybe will drive the point home. Here's a new one. Some of them are fairly mean critters. They can overcome resistance in some varieties that were already resistant. They can overcome resistance to some fungicides. So this is an ongoing issue.