Science Societies

Soil-sampling strategies for different tillage and fertilizer placement systems in Canada

By Joy Drohan

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Photo courtesy of Adobe Stock/Microgen.

Designing a soil-sampling program to use with different types of tillage and fertilizer placement systems can be challenging. Without careful planning to gather representative samples of the entire soil volume, growers may get skewed results. We spoke with five soil scientists and agronomists across

Canada and the Northern Great Plains to get their take on this important issue.

In much of Canada, many farmers are banding as much fertilizer as possible. This helps optimize investment in fertilizer, improves nutrient uptake, and reduces the chance of nutrient runoff, but the practice complicates optimal soil sampling. Without careful planning to gather representative samples of the entire soil volume, growers may get skewed high results that lead them to underapply nutrients and lose a crop's full potential, or skewed low results that lead to overapplication of fertilizer, wasting money and potentially polluting waterways.

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Zone Sampling

There was general agreement on the zone-sampling concept to assess soil nutrient variability of a large area. In zone sampling, growers sample each area of the field that has different management, topography, drainage, yield, or history, such as an area that was formerly a hedgerow but has been incorporated into a crop field. Each of these variables could introduce differences in the soil nutrient content, so each zone should be sampled separately.

The best way to identify the zones in a field, says Brian Hall, CCA in Milverton, ON, Canada, is to talk to the farmer before sampling begins about the differences they have noticed. During this conversation, crop advisers should work with the farmer to make a simple map identifying the zones. The map should indicate any coding used on soil sample bags to signify the various zones.



Photo by Jemila Chellappa.

Different crop advisers and soil scientists may recommend different sampling schemes based on geography, climate, and cropping system. But they agree that the more samples, the better.

They also agree on the importance of taking GPS coordinates for the center of a sampling plot or for each location sampled. This allows the same sites to be sampled over time and assures the grower that soil analysis trends show changes over time rather than spatial variability.

Effects of Fertilizer Banding, Deep Banding, and Tillage

Conservation tillage (no-till, minimum till, or strip till) with real-time kinematic (RTK) satellite navigation perpetuates horizontal and vertical stratification of nutrients. Strips and bands remain in the same location, and field traffic is controlled. Extra attention must be paid to accurately sample these soils and avoid under- or overestimation of crop nutrient reserves.

In theory, banding would build up high phosphorus bands in strips, says John Heard, CCA and soil fertility specialist with Manitoba Agriculture and Resource Development, but in practice, without RTK technology, the bands will drift a bit with each planting. Also, in Manitoba, he explains, if growers strip-till corn, for the next planting they typically move the row toward a row middle because the corn residue breaks down slowly, creating a problem for planting. The rotation might include a cereal such as wheat or oats in 6–10 inch rows. So, Heard says, “By the time we’re through a crop rotation with some row crops and some narrow rotating crops, we’ve essentially got the soil volume fertilized. That strip is a moving target.”

Fertilizer bands create variability on a microscale in “legacy” fertilizer strips. Farmers put down side-row bands or mid-row bands of fertilizer as well as fertilizer directly in the row. In planning a soil-sampling regime, Jeff Schoenau, professor of soil fertility in the Department of Soil Science at the University of Saskatchewan, says, “You want to have your bulk sample accurately represent the proportion in which those different bands and seed rows actually exist in the field.” So if your fertilizer band represents 20% of the seed bed area, ideally 20% of the soil in your composite sample from the surface depth should come from that residual fertilizer strip.

If you know or suspect that a field contains legacy fertilizer strips in conservation tillage, the following techniques can help prescribe sample placement and frequency throughout the zone. Recommended strategies differ depending on whether you know where the bands are.

1. Heard cites research by Fabián Fernández, extension soil specialist at the University of Minnesota working mainly in corn–soybean rotations. Fernández and a colleague developed a rule of thumb from extensive research in Illinois on sampling with *banded strip till where the rows are always in the same position.* They found that, in this situation, taking one sample in the row to every three samples between the rows adequately estimates soil fertility (**https://bit.ly/35kDgpK**). Fernández reports that he collects cores within a 10-ft radius that can be viewed as a point sample and is georeferenced to return for sampling in subsequent years. These techniques together give an accurate average of nutrients in the soil volume if you’re leaving the strip-till rows in the same place every year.
2. Research (**https://bit.ly/3o1vhnV**) by Newell Kitchen and colleagues in Colorado and Kansas determined that *if you know where your high phosphorus bands are*, you can use the following formula to determine how many samples to take off the band

for every sample you take in the band:

$S = 8[BS/(30\ cm)]$

“where *S* = the number of core samples to be taken between the bands (outside the influence of the band) for each core sample taken in the band to obtain the true mean, and BS = band spacing in cm” (p. 1664).



Photo by Upendra Sainju.



Photo by Matt Yost.

This relationship holds across different band spacings, phosphorus rates, and three central Great Plains soil types.

3. *If you know the direction of the bands but not their precise locations*, Kitchen and colleagues found that a paired sampling approach reduced variability over completely random sampling: Take one completely random sample and then move half of the distance between rows perpendicular to the band direction and take another sample.

In most cases, 10–30 subsamples composited is adequate for phosphorus soil test values. Kitchen and colleagues found that for soils with low potential phosphorus-fixing capacity, wide band spacing, or both, 30–60 subsamples should be composited to ensure that phosphorus values reflect the true field value.

Sampling Equipment

Fernández uses a soil probe to sample corn and soybean fields because it collects a uniform thickness of soil throughout the core.

There's recently been a move toward hydraulically operated soil samplers, which often fit on a truck or ATV. The depth accuracy is consistent, and sampling is quick and easy. But Hall notes that the accuracy of automated soil samplers is "only as good as the person behind the wheel." It's important to know where to sample to accurately represent the field's soil volume. He sends all of the sample for one composite to the lab where they have equipment for thorough mixing. This makes his job much faster and less prone to errors.



Photo courtesy of Aaron Daigh.

Hydraulic samplers are increasingly common on Canada's prairies. "Sampling down east can be child's play when probing only to 6 or 8 inches," Heard says. In the prairies, they probe at 0–6 inches and 6–24 inches to assess nitrate-nitrogen. A hydraulic sampler is almost essential for this sampling, especially with frozen soil.

Sample Depth

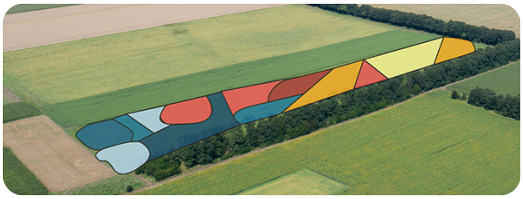
It's critical to take all samples for the same test(s) from a consistent depth—6 or 8 inches of soil for phosphorus and potassium, depending on the recommendations for your location. Fernández emphasizes that it's important to sample to the depth used by the institution that developed the recommendation because the fertilizer recommendations are based on the amount of nutrients present in a set depth of soil.

For fields where fertilizer is deep-banded, the sampling depth should capture the fertilizer band.

Sampling Frequency

Yearly sampling is ideal. Schoenau recommends testing every field every year, especially for available nitrogen, to get the maximum value in crop response and minimize environmental issues and also because nitrate levels can change quickly. He sees more farmers moving to that schedule.

"In strip tillage or where a farmer is banding most of their P or K needs," Hall says, "ideally my preference is to sample soil after wheat/cereal harvest in a [three to four year] crop rotation like corn–beans–wheat, which is common in eastern Canada, as there is not the same concern of hitting a fertilizer band, and wheat/cereals usually precede a more demanding crop such as corn or potatoes."



Known differences in soil properties and nutrient leaching and removal could be used to delineate zones to sample and manage separately. Photo courtesy of Adobe Stock/dechevm.

Halls says that in a corn–bean–cereal rotation, sampling once during the rotation is typically adequate, but that high-removal crops such as potatoes, vegetables, and alfalfa demand more frequent sampling than every three to four years.

Regardless of the frequency, sampling should be done at the same time in the rotation to ensure comparable data over time.

Heard says the need to know about nitrogen availability often drives the frequency of soil sampling. Phosphorus and potassium generally change slowly, but nitrogen levels can change annually based on crop removals and losses. He says that with the extreme drought in 2021 across much of the northern prairie, many growers found very high residual nitrogen at fall sampling. He hopes they can take advantage of that to reduce their fertilizer expenses this spring. But knowing this money-saving fact requires annual testing. Recent surveys of farmers in Manitoba show that more than 40% are doing some annual testing.

Fall is prime sampling season in all areas, but much more so in western Canada. In dry areas where nutrient leaching with moisture is not much of a concern, or where the soil is frozen throughout the winter, nitrate sampling can happen in the fall after harvest. This gives the CCA more time to develop thorough fertility recommendations. Some growers sample nitrate in spring and again in fall to look at uptake. In humid areas, nitrate sampling should happen in the spring.

Sampling for Sulfur and Micronutrients

Schoenau notes that sulfur can vary considerably across the landscape because it leaches downward with moisture and can also discharge as sulfate salts downslope. Discharge areas can have high available sulfate, so he would sample these areas as separate zones. The same can be true for micronutrients: known differences in soil properties, leaching, and removal across fields could be used to delineate zones to sample and manage separately.

Conclusion

"Any way you slice it," Schoenau says, "when you've got a lot of microscale variability from residual fertilizer strips in the soil, it takes additional effort to properly account for that" in soil sampling.

The techniques described here address the challenges raised by fertilizer strips in conservation tillage and will help deliver an accurate assessment of whole-field soil nutrients.

Felix Weber, president and CEO of Ag Business & Crop, Inc., in Palmerston, ON, suggests that the key to good soil sampling is consistency and longevity. "Whatever you do [for a soil-sampling program], do it precisely and consistently over a longer period. To me, that's the biggest takeaway."

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