

4. Sampling

Sampling soil

Farmers sample soil to:

- determine fertilizer and lime requirements
- diagnose problem areas
- monitor soil fertility levels

Sample collection

Soil can be sampled at any convenient time, but it is done primarily in the fall after harvest. This leaves enough time to get the analysis back from the laboratory and make plans for next season. For consistency, it's a good idea to sample soils at about the same time each year and following the same crops in the rotation.

Sampling every 3 years is enough for most soils. You may need to sample sandy soils more frequently, as nutrient levels may change rapidly. This is particularly true with crops that remove large quantities of potassium, such as tomatoes, silage corn and alfalfa. An effective approach is to sample one-third of your fields each year so that the whole farm is done once every 3 years. Where a particular fertility problem occurs, you should sample the area more frequently. Sample the good areas of the field separately from the poor areas.

You can choose to take a composite sample or several point samples. Composite samples represent the fertility of an entire field at lower cost.

The number of soil cores required to characterize a field depends on the topography and variability of soil within the field, the type of farm and the number and type of crops grown.

Taking samples

For standard Ontario fertility soil tests, soil cores are pulled from a depth of 15 cm (6 in.), as this reflects the fertility level of the soil where the bulk of most crop root systems are. Samples taken from a shallower depth will overestimate the nutrient levels, while deeper samples may underestimate them. In fields containing two or more distinct soil types, sample each type individually. Sample problem areas separately. To make sure the samples you collect are representative of the field, avoid sampling:

- in areas close to gravel or paved roads, since road dust will influence the soil test values
- in dead furrows
- on highly eroded knolls
- where organic waste or lime has been piled

If you are interested specifically in any of these areas, take a separate sample.

Note: It is impossible to split a sample of moist soil into two identical sub-samples without special equipment. Much of the variation in results between samples sent to different labs occurs because the samples really are different.

Use stainless steel

Use a commercial soil probe or auger that is stainless steel rather than galvanized. Pails should be clean and made of plastic or non-galvanized metal, especially if you are sampling for micronutrients. This will avoid contaminating the sample. Labs prefer to work with a full sample box, so collect enough soil to get a composite sample that will fill the box (see Figure 4–1).

Mix

Mix the cores together thoroughly in the pail, crushing clods and removing stones and crop residue. Fill the sample box or bag with a representative sample from the soil. Careful sampling and mixing is essential to ensure the accuracy of the composite sample.

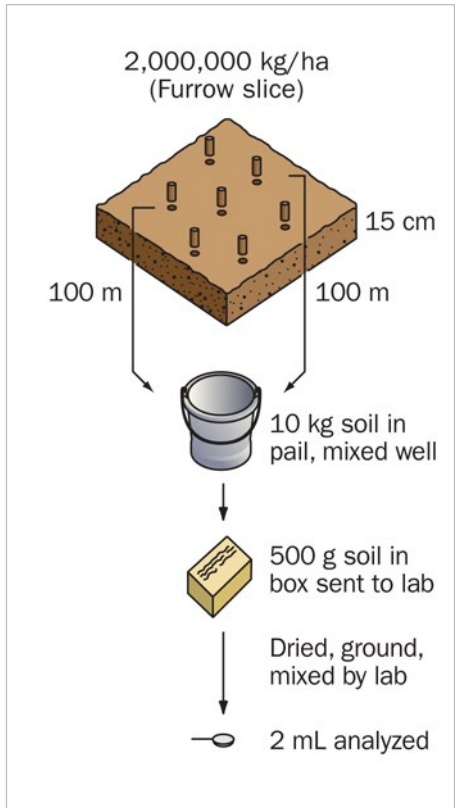


Figure 4–1. Field to pail to lab

Exception — sampling for nitrate

Soil nitrate is not included in a regular soil test. Instead, nitrogen recommendations included on most soil test reports are based on your crop plans.

Timing of nitrate samples is critical because soil nitrate levels will vary greatly throughout the year due to leaching and microbial activity. Collect samples at planting time for corn or barley or before side-dressing corn. Sample collection at side-dressing will detect more of the nitrate from organic sources such as manure or legumes. Nitrate samples are taken at a 30 cm (1 ft) depth. Follow the same sampling pattern and mixing procedure as for a standard soil sample.

Handle the soils with care. They should be stored at temperatures below 4°C until they are analyzed. Soil storage at 4°C for periods ranging from 1–7 days was compared to either freezing or air drying the soil samples before extraction in a 2007 study involving 66 soils from Ontario (Oloya et al., 2007).

One day after sampling, about 70% of the inorganic nitrogen was in the nitrate form and the remaining 30% was ammonium. As the moist soils were stored at 4°C for longer periods, ammonium was slowly converted to nitrate through the nitrification process (Figure 4–2). This conversion would have been even greater if the soils were stored at room temperature.

Freezing increased soil ammonium levels by 22%, and air drying increased soil ammonium levels by 37%. Soil nitrate levels were also increased but to a lesser extent. Therefore, freezing or air-drying is not recommended, especially when ammonium values are of interest.

It is recommended that the soils be stored at 4°C and extracted field moist within 4 days of sampling.

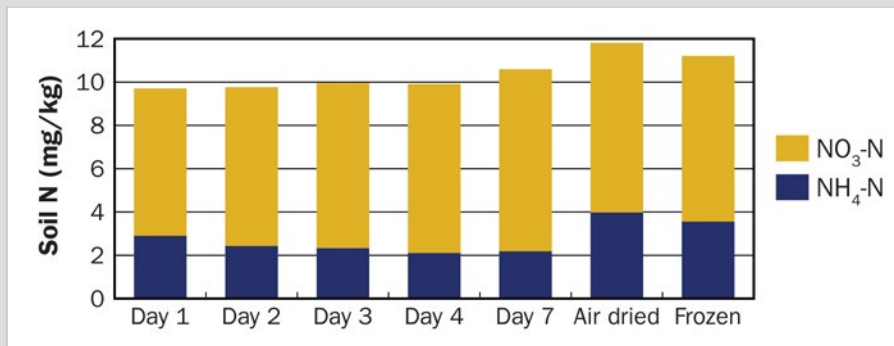


Figure 4–2. Impact of sample handling on soil mineral N content.

Source: Oloya, T.O., C.F. Drury and K. Reid, 2007

is management, particularly the amount and type of fertilizer and manure applied to each field over the years. It is difficult to predict which nutrients might be limiting yield in a particular field without a soil test. The goal of a soil sampling program is to predict the most profitable rate

of fertilizer for the field or part of a field. To design a good program, it is important to know the potential for economic return to management, the probable variability within each field, and the resources available (see Chapter 7 for more information).

What causes soil to vary?

Variability stems from the soil-forming factors (parent material, topography, biological activity, climate and time) as well as from management history (tillage, fertilization and crop residues).

Tillage-induced variation is created when the mouldboard plow and other implements pull soil off the tops of knolls and deposit it downslope. This creates areas on the knolls of low organic matter, low fertility and often higher pH (see Figure 4–4).

Several years of applying fertilizer and manure unevenly may also create variability in soil fertility. The consolidation of small fields into larger ones makes the variation greater. When crop residues are left unevenly distributed, they also contribute to variable soil fertility.

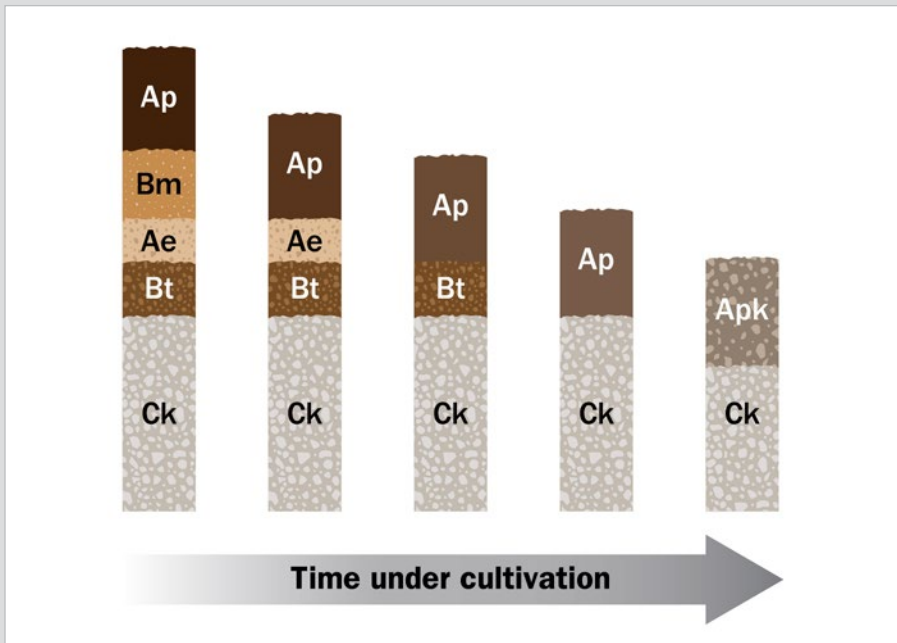


Figure 4–4. Soil profile change on a knoll over time due to tillage-induced erosion. Mixing of Ap horizon with Ck horizon results in an Apk, which has diluted organic matter and elevated soil pH.

Sampling strategies

Composite samples

The most common soil sampling strategy is to take one composite sample from each field (see Figure 4–5). Usually the maximum field size for a composite sample is 10 ha (25 acres). The number of cores in each composite sample should be at least 20, no matter how small the area, to average out small-scale variations. This strategy is appropriate where:

- the value of the crop is low
- there is low potential for return to variable fertilization
- there is little variation in soil fertility
- the entire field is high enough in fertility that no response to fertilizer is expected

In the case of very low soil test levels from a field, it is generally safe to assume that the entire field will respond to fertilization. If the test levels of the composite sample are very high, it is likely that while there will be considerable variation, the whole field will be high enough so that even the lowest-testing areas will not likely respond to added fertilizer.

For a more complete discussion of the development of Ontario’s soils, see the OMAFRA/Agriculture and Agri-Food Canada booklet *Best Management Practices — Soil Management*.

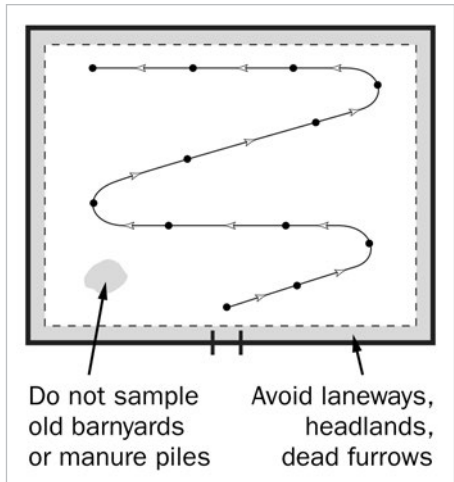


Figure 4–5. Composite sampling

Georeferencing (*grid sampling*)

Georeferencing, or systematic soil sampling, uses global positioning system (GPS) technology and geographic information system (GIS) techniques to collect soil sample data and present it in map form (Figure 4–6). This technique has been called grid sampling. The most common spacing between sample sites is 1 ha (2.5 acres).

A common practice is to create a field boundary with GPS and mapping software. A grid pattern is superimposed on the map to serve as a guide for sample collection. Each sample point is logged. The evenly spaced sample points allow a degree of statistical validity.

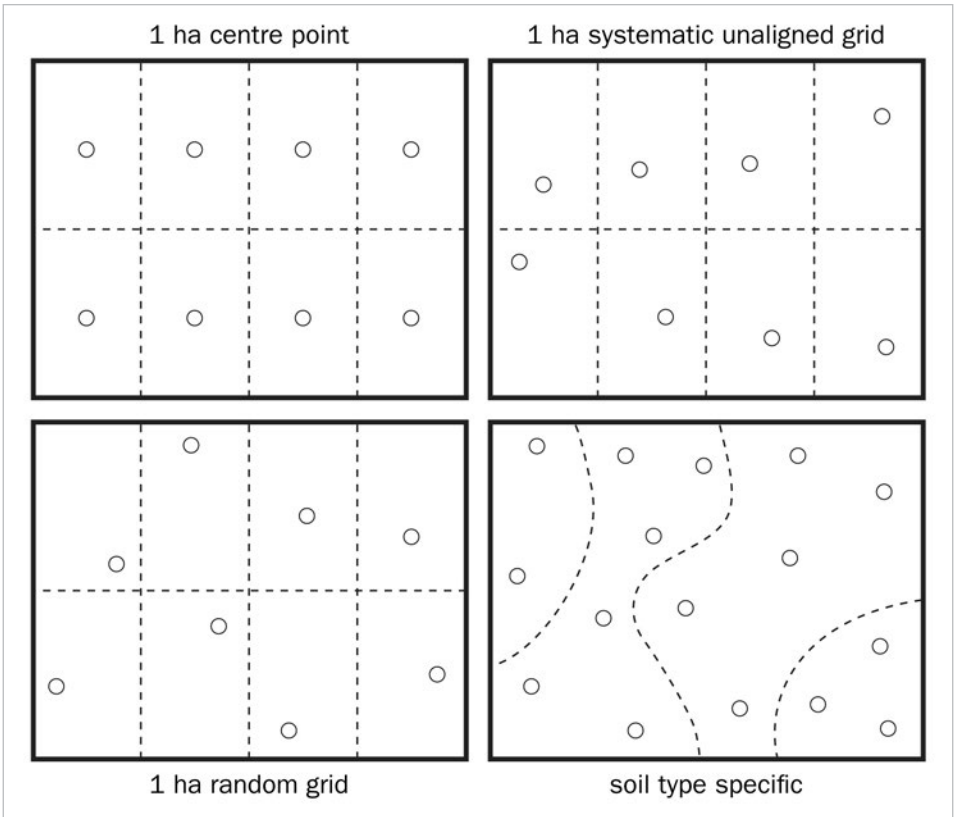


Figure 4-6. Georeferenced sampling

After lab analysis, the nutrient values from each sample are merged with the map data using GIS software. Comparing the information from a 1 ha sampling scheme to that of composite sampling on a 40 ha (100 acre) field would give 40 sample values versus a typical composite plan of four. Having 10 times more data represented in map form heightens the awareness of the spatial variability of nutrients, which may affect management decisions.

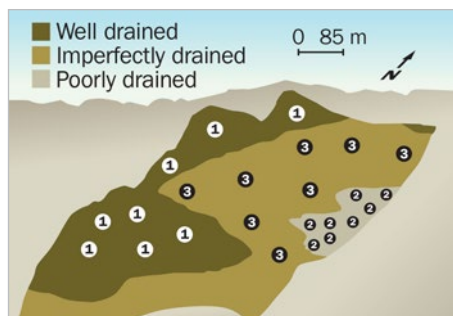


Figure 4–7. Basic management zones based on topography and drainage

Management zone samples

A growing practice is sampling by management zone, which involves taking a composite sample from distinct areas of the field that can be managed separately.

Grid sampling may be suitable to provide a baseline understanding of management zones but generally does not align with variability. Subdividing a field into zones according to soil type or series, texture, topography, drainage and/or crop characteristics is the preferred approach. A simple method is to sketch the known variation in texture or topography (see Figure 4–7), field history or manure history on a map, and sample those areas separately. This does not allow for automated generation of prescription application maps but may be suitable for some operations.

Measurements from yield or elevation maps or data generated by crop or soil sensors can be used to create management zones. Elevation data can be acquired from the guidance system on a farm implement — a high-quality GPS signal is best.

Normalized yield maps can also be used to determine areas of the field that are consistently lower or higher yielding, according to single or multiple crop types. Yield maps can be used with other maps and farmer knowledge to refine sampling zones. Once management zones are defined and sampled, the assignment of input prescriptions requires agronomic knowledge to match recommendations to the soil test characteristics of the specific zones.

For more detailed information on defining management zones, refer to the Soil Fertility and Nutrient Use chapter of Publication 811, *Agronomy Guide for Field Crops*.

Special sampling conditions

No-till

Fertilizer recommendations are based on the nutrient content of the top 15 cm (6 in.) of soil. Therefore, sampling depth for nutrients is the same in reduced tillage systems as in conventional tillage. Nutrient stratification can occur under no-tillage systems.

The exception to this is soil pH. Where nitrogen is surface-applied in a no-till system, a shallow layer of acidic soil may develop. A separate, shallow sample (5 cm (2 in.)) can be taken to check for this. **Note:** adjust for the shallow depth of sample when using the liming recommendations in Chapter 3, Table 3–2.

No-till, strip-till, banded fertilizer and injected manure

Fields in long-term no-till or strip-till with a history of banded fertilizer or injected manure pose extra challenges because nutrient additions are concentrated in parts of the field.

Table 4–1 can be used as a guide for collecting soil samples from fields with a history of banded nutrients. The sampling strategy in these scenarios involves collecting samples from concentrated nutrient areas of the field in a proportion that reflects the volume of soil that they occupy.

Collecting soil samples for problem diagnosis

Where soil fertility is suspected as the cause of reduced crop growth or yield in part of the field, it is important to sample these areas individually to confirm your diagnosis. Sample nearby good areas and compare them with the problem areas. Be sure to take at least 8–10 cores for each composite sample to ensure the sample is representative of the area. Nutrient deficiencies in plants may be due to either inadequate concentration of nutrients in the soil or inability of the plant to access the nutrients due to restricted root volumes. Any problem diagnosis should consider both of these factors.

Keep a detailed record of the location of problem spots. Continue sampling problem areas every year or every other year until the fertility levels are adequate.

Table 4–1. Sampling guidelines to account for banded nutrients

Band spacing	Placement	Collect
76 cm (30 in.)	planter	1 core within the band for every 20 out of the band
30 cm (12 in.)	planter	1 core within the band for every 8 out of the band
76 cm (30 in.)	strip till, manure injector	1 core in the zone for every 3 out of the zone, where zone of influence is 25 cm (10 in.) wide
unknown	planter	paired sampling: 1 random core followed by a second core 50% of the band-spacing distance from the first sample, perpendicular to the band direction
to determine with any spacing	planter	$S = 8 [x \div 30 \text{ cm}]$ ($S = 8 [x \div 12 \text{ in.}]$) where S = number of cores between bands (outside influence of band, 5 cm for planter placed fertilizer) x = band spacing in cm or inches

Source: Publication 811, *Agronomy Guide for Field Crops* (2017 edition)

Sampling plant tissue

Farmers sample plant tissue from:

- perennial tree fruit, berries and grape crops to determine fertilizer recommendations
- annual crops to diagnose fertility problems, particularly micronutrient deficiencies

Tree fruit, berries and grapes

Take tissue samples from fruit trees between July 15 and 31. Take samples of grape petioles between September 1 and 15. These dates correspond to standard nutrient levels of mature leaves (Table 4–2), against which your tissue samples will be compared in the lab.

Table 4–2. Recommended timing and plant parts for tissue sampling

Crop	Timing	Plant part
cereals	at heading	top 2 leaves
corn	3–5 leaf stage	whole plant (zinc and phosphorus only)
	silking	middle third of ear leaf
edible beans	first flowering	top fully developed leaf (3 leaflets + stem)
forages	late bud	entire above-ground portion
soybeans	first flowering	top fully developed leaf (3 leaflets + stem)
broccoli, cauliflower	start of head formation	midrib of young, mature leaf
cabbages	at heading	midrib of wrapper leaf
carrots	mid-growth	petiole of young, mature leaf
celery	mid-growth	petiole of newest elongated leaf
lettuce	at heading	midrib of wrapper leaf
onions	minimum 3 times/season	tallest leaf
potatoes	early, mid or late season	petiole of 4th leaf from tip
spinach	mid-growth	petiole of young, mature leaf
sugar beets	12 weeks	youngest mature leaf
tomatoes	early bloom	petiole of 4th leaf from tip
blueberries	late July-early August	mature mid-shoot leaves of current year growth
grapes	September 1–15	petioles from mature leaves of fruiting canes, remove leaf immediately
raspberries	late July	fully expanded leaves from fruiting cane
strawberries	fruiting plants: late June non-fruiting plants: early-to-mid-August	fully expanded recently matured leaflets only (remove petiole immediately)
tree fruits	last 2 weeks of July	mature mid-shoot leaves of current year growth at shoulder height
tobacco	at topping	10th leaf from top

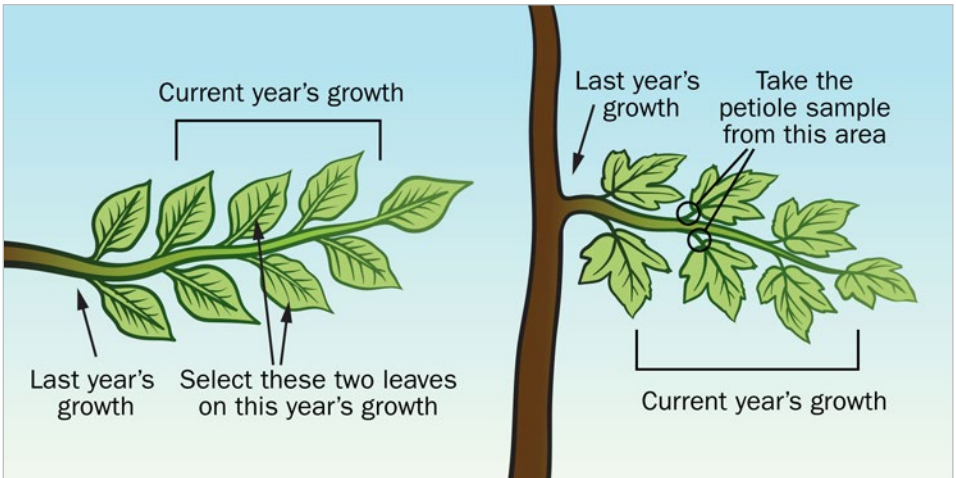


Figure 4-8. Where to sample

Sample each cultivar, age, rootstock, and block of fruit trees separately. Collect at least 100 leaves for each sample. The best way to get a representative sample is to take 5 leaves each from 20 trees. Do not combine healthy and unhealthy leaves. See Figure 4-8.

To sample grape vines, select only the stems (petioles) of mature leaves. Keep cultivar, rootstock, and blocks of different ages separate. Ideally, collect petioles from a number of different rows in a block. Collect at least 100 petioles for each sample. For *Vinifera* and French hybrid varieties, collect 150 petioles.

Field-grown crops

Take samples from at least 50 plants collected randomly from across the field. Keep in mind the lab needs at least a 250 g (9 oz) fresh weight sample.

Use Table 4-2 to find the right time to sample, as you want your samples to be comparable to the standard values. Collect samples from the appropriate location on the plant according to its growth stage (Table 4-2 and Figure 4-9).

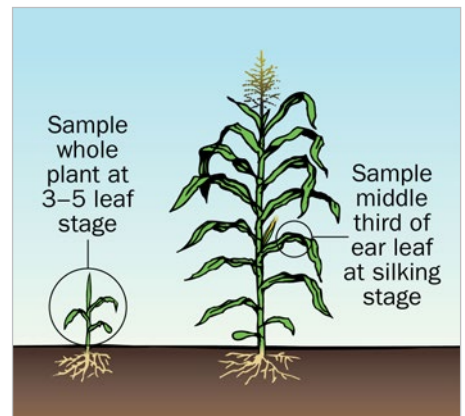


Figure 4-9. Where to take tissue samples for corn

Sampling recommendations for horticultural and field crops

The most common errors in collecting plant tissue samples are:

- not collecting enough material
- collecting chlorotic or dead tissue or insect-damaged leaves
- collecting plant tissue contaminated with soil
- shipping the sample in plastic bags

Do not sample tissue to which foliar fertilizers have been applied.

Collecting tissue samples for problem diagnosis

Tissue samples can be valuable for confirming nutrient deficiencies in plants, particularly for micronutrients. Follow proper sampling technique, as described earlier, and be sure to collect a large enough volume of plant tissue that the analysis can be completed. Sample separately from normal growth (good) and affected (poor) areas. Do not sample dead plants (see Figure 4–10). Take soil samples from the same areas to check pH and nutrient status.

To get a diagnosis, you may have to sample outside the recommended times, and thus the nutrient contents may not necessarily correspond to the values at the standard times. Compare healthy and affected areas. Critical values for tissue concentration may be misleading in any case, since the concentration of nutrients in unhealthy plants may be high simply because there is not enough tissue to dilute the nutrients.

Shipping

Put leaf or petiole samples into paper bags, not plastic, or they will sweat and rot. Label each bag so that you will be able to relate the analysis to the specific block in the orchard or location in the field.

Keeping records

Keep records of each block or field sampled, including variety and year. Keep the analysis with the records of fertilizer applied, weather conditions and final yields. This will help determine trends in fertility levels.

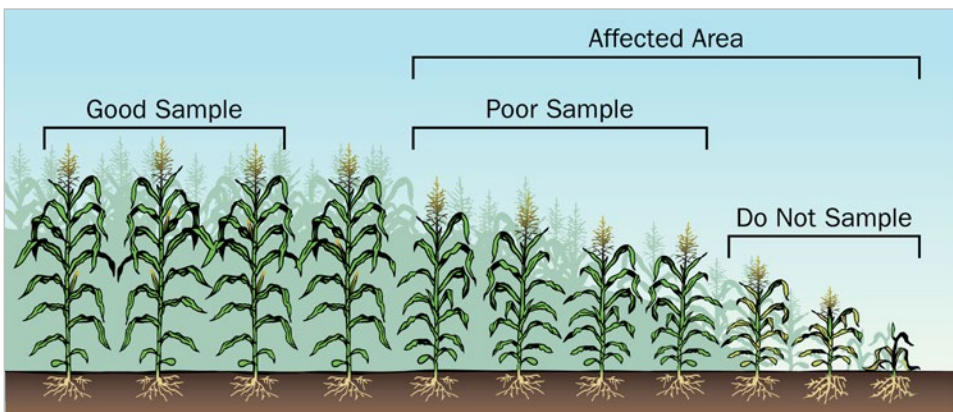


Figure 4–10. Tissue sampling to diagnose problems

Sampling manure

Farmers sample manure to:

- determine, in advance, the amount and kind of nutrients to be applied
- help determine requirements for additional nutrients

Sampling liquid manure

For liquid manure, take a sample each time the storage is emptied until you gain a sense of the average nutrient values. Manure applied from a storage emptied in spring will be different from the manure applied from the same storage emptied in late summer.

Agitate the storage completely. In a plastic pail collect samples from various depths of the storage, as it is being emptied. Mix 10–20 of these samples thoroughly and transfer a portion to a plastic jar.

The jar should only be half full to avoid gas buildup and explosion. Seal it tightly and put it in a plastic bag that is securely tied.

Store the sample in a cool place until shipping.

Sampling solid manure

For solid manure, take a sample every time the storage is emptied until you gain a sense of the average nutrient values. Then you can sample every few years or when you make a major change in manure source or in management, such as changes to ration, bedding or storage methods.

Solid manure is more difficult to sample randomly. On clean cement or plywood, take samples (a forkful) of manure from various loads leaving the pile or from various parts of the pile. Chop the manure with a shovel or fork and mix the samples together as thoroughly as possible. Divide the manure into four portions and discard three.

Continue mixing and dividing the manure until you can fill a plastic jar or shipping container — about half a litre.

Place the tightly covered sample in a plastic bag and store it in a cool place until shipping.

Ship manure samples early in the week so that they reach the lab before the weekend.

Manure varies from farm to farm

Several factors affect the quantity of nutrients in manure. Some classes of livestock have manure with higher nutrient content. For example, poultry manure usually has a higher value for all nutrients than dairy manure. Within the poultry category, broiler manure is usually higher in nutrient value, especially phosphorus and potassium, than manure from laying hens.

The nutrient content of manure usually reflects the type of ration being fed to the livestock. Thus, manure from young animals being fed a concentrated ration has a higher

nutrient content than livestock fed a lower-quality feed. Properly balanced rations give optimum performance with the least throughput into the manure.

The amount and type of bedding affects the concentration of nutrients in the manure. Wood chips or wood shavings have a higher carbon-to-nitrogen ratio (500:1) than grain straw (80:1). The higher the carbon-to-nitrogen ratio, the more nitrogen can be tied up while carbon compounds are being broken down, which affects the amount of crop-available nitrogen.

Added liquids from any source dilute the nutrient concentration of the manure. A dairy manure with added milk house washwater and yard runoff needs a much higher application rate for similar nutrients than, for example, hog manure from a barn with wet-dry feeders.

Losses from storage can have a large impact on the nutrient content of manure. Runoff from a solid manure pile can wash away a significant portion of the nitrogen and potassium, while most of the phosphorus remains bound in solid forms. This is not only an environmental risk but a waste of resources.

Sampling to diagnose deficiencies and toxicities in the field

Explaining trouble spots in a field requires an open mind and examination of all the information available. When scouting a field for problems, check:

- soil for differences in structure, texture, horizons, compaction and the standard soil fertility analysis
- plants for growth stages, varieties, planting dates, planting depths, tissue colours suggesting deficiencies and disease, root development
- for pests like weeds, insects and diseases and for pest-control effects

Follow up with an overview of the crops in the area. Look at a circle of at least one concession to see if the problem is specific to one field or a general issue.

Do an overview of the entire field before moving to the specific site. Compare the good to the poor if you can. Look for patterns that can help identify the causes of poor growth:

- **strips or rectangular patterns.** These suggest application problems, particularly if they are repeated across the field.
- **vector-driven diseases.** Barley yellow dwarf, for instance, can be distributed by insects that sometimes float in on the prevailing wind and leaves a pattern much the same as snow drifting across the field. If the area

in the shadowed side of trees is unaffected, that's an indication of something being vector-driven.

- **the impact of wheel tracks.**

These can be positive or negative. Normally, wheel tracks cause compaction and poor growth. Generally, areas can be measured and compared to the wheel spacing from weight-bearing wheels on farm equipment. However, on occasion slight packing from wheel traffic may improve seed-to-soil contact, resulting in earlier emergence, particularly on very loose soils.

Patterns can be difficult to see if they appear and disappear. Sometimes the problems are not severe, but if soil or weather conditions within a field change just a little, they may worsen. For example, soybean cyst nematode may not show symptoms in a field for years despite a gradually increasing population. It may finally give rise to typical symptoms in sections of the field where there is another stress such as compaction.

Look at crop production records for general trends in yield or quality. Whether a problem manifests in all crops in the rotation or only one can provide hints about the cause of the problem.

References

- Oloya, T.O., C.F. Drury and K. Reid, 2007. Effect of soil storage on soil extractable ammonium and nitrate levels. Unpublished data.
- Potash & Phosphate Institute, 2006. *Soil Fertility Manual*. PPI/PPIC, Norcross, GA 30092-2837 USA.
- Rehm, George W., Antonio Mallarino, Keith Reid, Dave Franzen, John Lamb, 2002. *Soil Sampling for Variable Rate Fertilizer and Lime Application*. NCR-13 Committee, available from University of Minnesota (<https://store.extension.iastate.edu/product/Soil-Sampling-for-Variable-Rate-Fertilizer-and-Lime-Application>).

