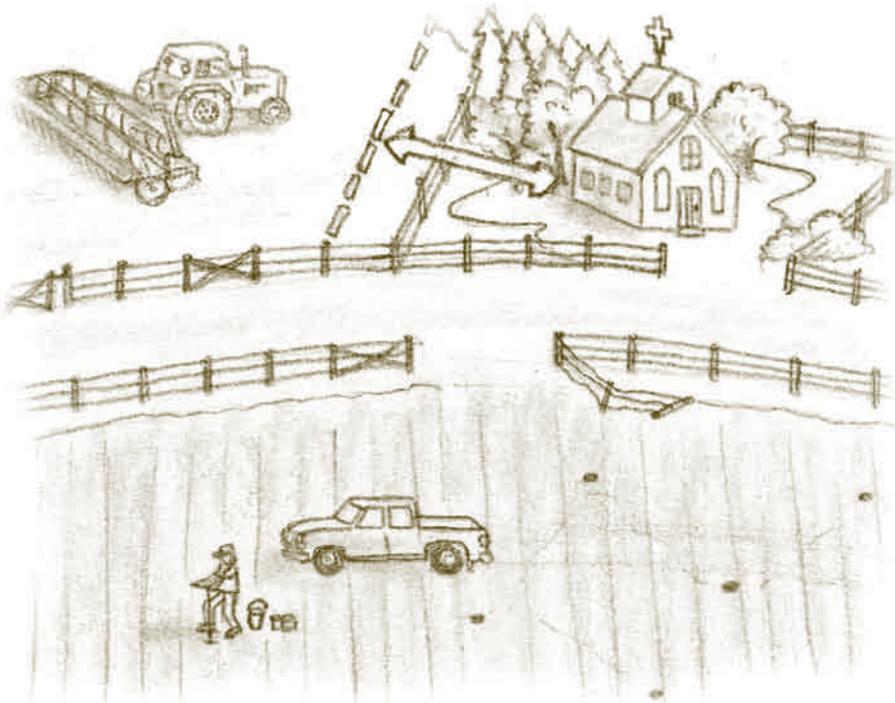


# Chapter 3.3

## Soil Sampling



### ➔ learning objectives

- Choose appropriate times to sample and list **five sampling strategies**.
- Describe the appropriate depth and frequency for sampling.
- **Understand how to preserve the quality** of samples prior to shipping to a soil testing laboratory.
- List the tests included in a recommended soil sample analysis.
- List information to submit to the lab in **order to improve the reliability of fertility** recommendations.



## Important Terms

Table 3.3.1 Key Terms and Definitions

Term	Definition
Fallow	The practice of leaving the land uncropped and weed free by means of tillage or chemical vegetation control.
Immobile Nutrients	Nutrients having a very low mobility due to low solubility.
Legume	A plant of the botanical family <i>Leguminosae</i> (e.g., pea), which has the ability to fix atmospheric nitrogen through a symbiotic association with <i>Rhizobium</i> .
Nutrient Transformation	The process where by a nutrient is changed from one form to another form (e.g., $\text{NH}_4^+$ changed to $\text{NH}_3$ ).
Remote Sensed Image	The term generally refers to images (e.g., photos, color infrared, maps) that are generated through the use of instruments aboard aircraft and spacecraft.
Residue or Crop Residue	The portion of plant material remaining in the field after harvest (e.g., straw, roots, stems)

Proper soil sampling is required for accurate soil analyses and reliable nutrient recommendations. Soil analysis provides a “snapshot” of nutrient reserves in the soil, and can be a guide for nutrient applications. Soil samples submitted for analysis should be representative of the field. Obtaining representative samples can be difficult because of soil variability. To get a representative soil sample consider:

- Timing of sampling
- Sampling tools
- Sampling depth
- Sampling frequency
- Sampling strategy or parts of fields to sample
- Appropriate handling of samples

## Timing of Sampling

The ideal time to assess soil nutrient status is just before a crop is actively growing and needs soil nutrients. Use the following guidelines to select an appropriate time to sample:

- For spring-sown annual crops collect samples early in spring as soon as the soil has thawed or in the fall once soil temperatures have dropped below 5 to 7 °C (e.g., late October).

- For establishing perennial or fall-sown crops, collect samples about a week prior to seeding and fertilizing.
- In fields with established perennials, sample annually in the spring before active growth begins.

### Fall Sampling

If spring sampling is not possible, sample in the previous fall after soil temperatures drop below 5 to 7°C. When soils cool to this range, soil microbial processes that affect crop available nutrients (e.g., mineralization) slow down. Consequently, further changes in plant available nutrient levels are minor. Fall sampling allows time to properly process samples, and get test results and nutrient recommendations to develop nutrient application strategies.

In most areas of Alberta, it is generally safe to begin fall sampling by the middle of October. Fall sampling in forage fields can begin anytime after September 1<sup>st</sup>.

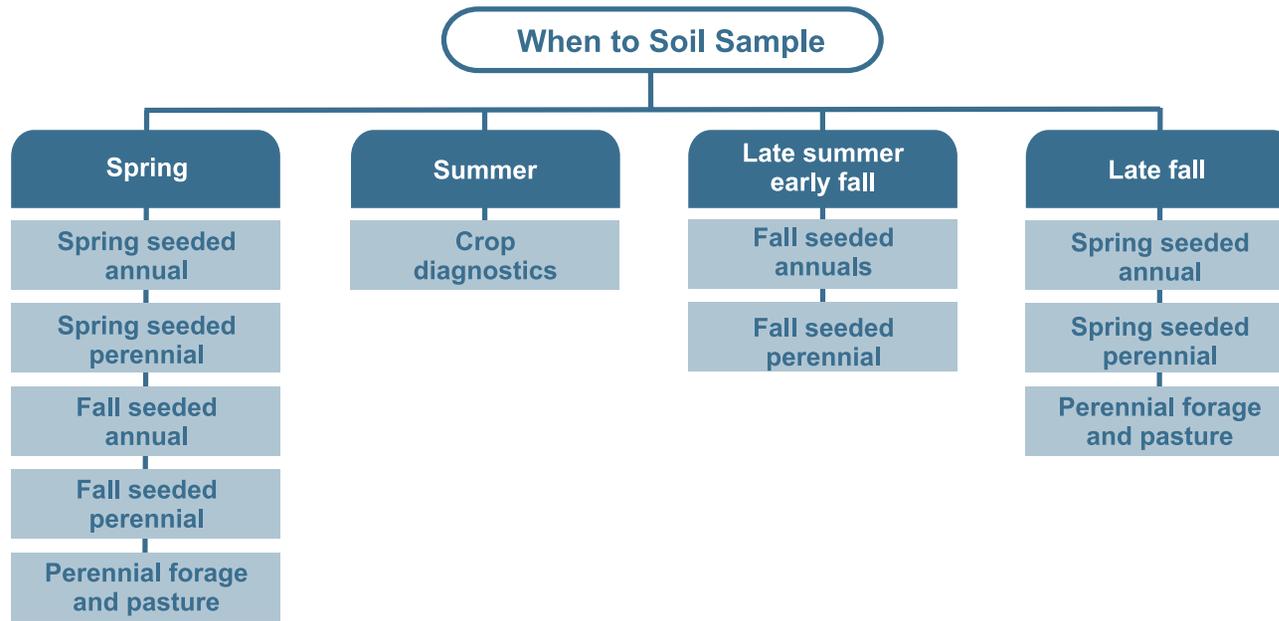


Figure 3.3.1 Timing of Soil Sampling

Source: Kryzanowski, 2007

**s i d e b a r**

**Always sample fields prior to nutrient application. Collecting representative samples from fertilized or manured fields is more difficult.**

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**s i d e b a r**

**Avoid sampling frozen or water-logged soils. It is difficult to obtain representative samples for these conditions.**

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tip



Before sampling or having a field sampled, be sure to identify the location of any underground utilities. Failing to identify these can result in personal risk and financial liability.

Call Alberta One-Call at 1-800-940-3447 before sampling to have underground utilities identified.

tip



Core samplers allow reliable separation of sampling depths. Auger type samplers result in too much mixing between sample depths, resulting in poor soil samples.

## Sampling Tools

Soil sampling tools (Figure 3.3.2) can be purchased from equipment supply companies. Alternatively, sampling equipment can be borrowed from fertilizer dealers, private labs, or crop advisors. For samples deeper than 30 cm (1 ft) truck mounted hydraulic coring equipment is recommended. Many fertilizer dealers offer soil sampling services.



Photos courtesy Crystal Korth, AF and Natural Resource Conservation Service

Figure 3.3.2 Manual and Truck Mounted Soil Sampling Probes

To collect a quality sample, insert the sampling probe straight into the ground (Figure 3.3.3). Avoid inserting the probe on a slant, because this will reduce the accuracy of the sample.

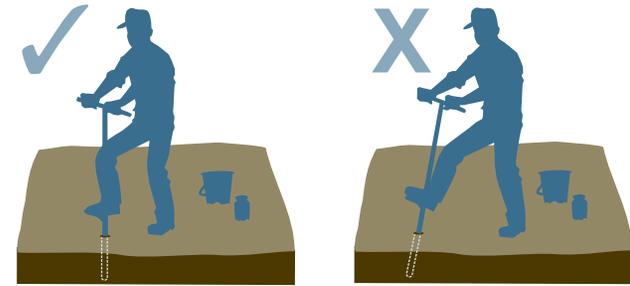


Figure 3.3.3 Correct and Incorrect Insertion of a Soil Sampling Probe

## Sampling Depth

It is recommended that samples be taken from the following depths to get the best estimate of soil nutrient levels to optimize nutrient management:

- 0 to 15 cm (0 to 6 in)
- 15 to 30 cm (6 to 12 in)
- 30 to 60 cm (12 to 24 in)

Soil testing laboratories can develop fertilizer recommendations from a 0 to 15 cm depth sample, but these recommendations make assumptions about nutrient content in deeper layers. More reliable fertility recommendations and better nutrient management decisions can be made when nutrient levels are measured rather than estimated (e.g., for nitrogen and sulphur).

## Sampling for Nitrate and Sulphate

Nitrate nitrogen ( $\text{NO}_3\text{-N}$ ) and sulphate sulphur ( $\text{SO}_4\text{-S}$ ) are mobile nutrients that may be found in significant amounts in the 15 to 60 cm depth. Therefore, N and S fertility recommendations should be based on extractable  $\text{NO}_3^-$  and  $\text{SO}_4^{2-}$  contents in a 0 to 60 cm deep soil sample. Nitrogen and S recommendations could be incorrectly estimated if they are solely based on a 0 to 15 cm depth sample. Separate sample depths provide more reliable estimates of  $\text{NO}_3\text{-N}$  and  $\text{SO}_4\text{-S}$  in the soil profile.

## Sampling for Phosphorus and Potassium

Phosphorus and K recommendations are based on the amounts of crop available P and K contained in the 0 to 15 cm depth sample. Generally, most of the plant available P in soil is confined to the plow layer because P is relatively immobile.

## Sampling Frequency

Ideally, all fields should be sampled and tested annually, but this may not always be practical. Alternatively, samples may be taken from representative fields and the resulting recommendations can be used to manage unsampled fields. Fields could also be sampled every other year, with estimates used in years between samplings to make fertility decisions. In both cases, the cost and time requirements associated with sampling are reduced; however, nutrient management decision-making may be less precise.

## Sampling Strategies

Soil variability is a major concern when trying to obtain a representative soil sample. The strategy used to sample a field can address this challenge. Information collected during a site assessment can assist in choosing an appropriate strategy for a particular field.

Some of the sampling strategies that can be followed include:

- Random composite sampling
- Directed random composite sampling
- Benchmark sampling
- Landscape-directed benchmark sampling
- Grid sampling

### General Soil Sampling Guidelines

For any soil sampling strategy:

- Take 15 to 20 cores for each representative bulk sample. This number of samples is based on statistical precision.
- Each core will be segmented into lengths that represent depths of 0 to 15 cm, 15 to 30 cm and 30 to 60 cm.
- Separate the segmented cores by depth into clean, labeled plastic pails. Thoroughly mix the content of each pail, crushing any lumps in the process. Avoid using metal pails to collect samples because they can alter the results of micronutrient tests.
- Take a single sub-sample (0.5 kg) for each sampling depth and submit for analysis.
- For hilly fields with knolls, slopes, or depressions, take samples from mid-slope positions to get a representative sample of the field average.
- Avoid sampling obvious areas of unusual variability such as: saline areas, eroded knolls, old manure piles, burn piles, haystacks, corrals, fence rows, old farmsteads or any other unusual areas.
- Soils within 15 m (50 ft) of field borders or shelterbelts and within 50 m (150 ft) of built-up roads should be avoided or sampled separately.
- Always sample prior to manure or fertilizer applications.

## sidebar

**Under AOPA, fields that will receive manure must be soil tested a minimum of once every three years.**



## sidebar

**Recall that soil analysis requirements under AOPA require a sample representing the entire 0 to 60 cm (0 to 24 in) depth to measure  $\text{NO}_3\text{-N}$ .**

more info



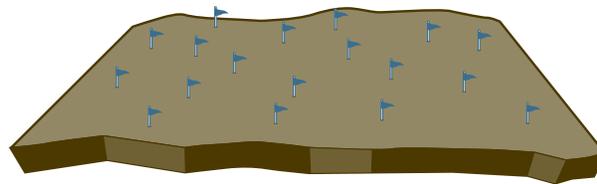
A list of labs that analyze soil samples is included in the Appendices.



**Random Composite Sampling**

Random composite sampling involves taking samples in a random pattern across a field, while avoiding unusual or problem soil areas (Figure 3.3.4). This strategy is most appropriate for fields less than 30 ha (80 ac), that have been uniformly cropped in the recent past and have little natural variation. This is the most common method of sampling presently used in Alberta.

For random sampling, collect cores from 15 to 20 sites and separate each core by depth (see General Soil Sampling Guidelines) to obtain representative bulk samples for each depth.



▤ = Probe site

Figure 3.3.4 Random Composite Sampling Pattern.

**Directed Random Sampling**

Directed or managed random sampling is a modified version of a random sampling strategy (Figure 3.3.5). This pattern is suited to fields or areas where it is difficult to identify a single dominant area that would represent most of the field.

Sub-divide the field into management zones based on unique characteristics. For instance, if there are noticeable differences in yield throughout a field, management zones might be comprised of below-average, average and above-average yielding areas. Take 15 to 20 cores (see General Soil Sampling Guidelines) randomly from each management zone. A single field may require several bulk samples depending on the number of management zones.

This strategy might also be appropriate for areas with more than one soil type, fields with hummocky (rolling) landforms, and fields under strip-crop management.

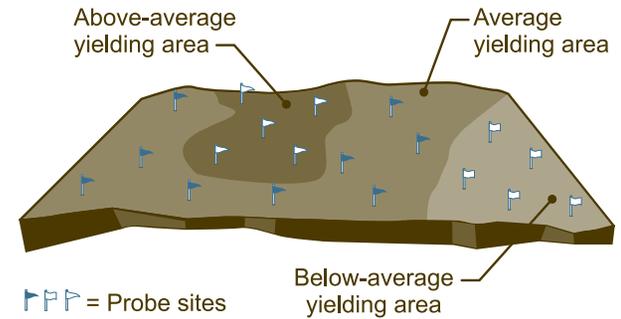


Figure 3.3.5 Directed Random Sampling Pattern

**Benchmark Sampling**

Benchmark sampling involves selecting a small (30 m by 30 m) representative site on a field (Figure 3.3.6). This site is used as a guide for fertilizing that entire field. Select probe sampling sites in a grid pattern within the benchmark area and prepare a composite sample for each soil depth. Sampling from the same small area each year reduces sampling variability and better reflects changes in soil nutrient level from year to year. Benchmark sampling sites should be marked with a GPS or by other means.

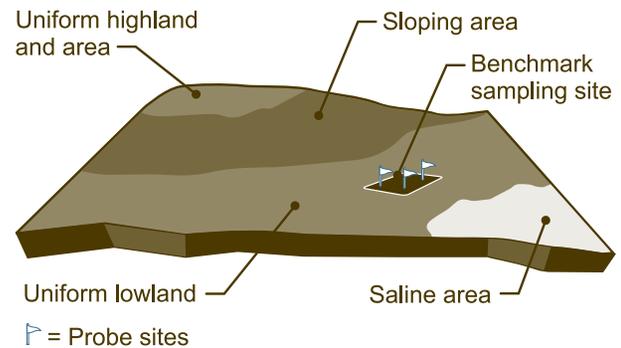


Figure 3.3.6 Benchmark Sampling Pattern

When first using this strategy, it can be difficult to select a benchmark site that best represents a field. Therefore, in the first year, it may be necessary to sample and analyze a number of potential benchmark sites. Initially, the costs for laboratory analysis will be higher but the most representative benchmarking site will be identified. If a single site does not adequately represent a field, it may be necessary to maintain multiple benchmark areas (i.e., directed benchmark sampling, see next section).

### Selecting a Benchmark Site

When selecting a benchmark site, look for features such as soil colour and landscape to identify where different soil types occur. Select a site that has characteristics similar to most of the field or the dominant soil type.

Observe crop development patterns to assist in identifying different soil conditions. At the beginning of the growing season differences in crop establishment and vigor are more apparent, making a representative location easier to identify. Potential benchmark sites can also be selected based on yield, aerial photos or topographic maps.

Benchmarking is rapidly gaining popularity in Alberta, particularly with increased use of GPS. GPS coordinates help to identify and locate the benchmark site for sampling each year.

### Directed Benchmark Sampling

Directed benchmark sampling is a variation on the benchmark technique. It involves establishing multiple benchmark areas and management zones, based on topography or other characteristics (Figure 3.3.7).

This strategy can be used when major areas within fields have distinct and well-defined features related to

moisture (e.g., texture, slope). Management zones can be identified using soil surveys, detailed elevation mapping, aerial black and white photographs, yield maps or remote sensed images.

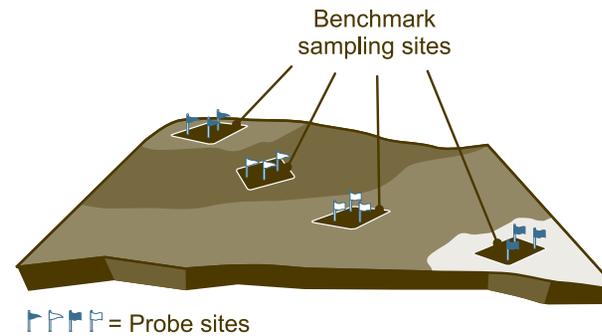


Figure 3.3.7 Landscape Directed Benchmark Sampling Pattern

Directed benchmark sampling is only warranted if distinct areas are managed individually. For example, a soil analysis from a benchmark site in a low area suggests that it might respond to higher rates of N compared to a benchmark site on an upland area. Even without variable rate application capabilities, N application could be increased by other means to optimize yield in low areas.

### Grid Sampling

Grid sampling is the most intense and expensive sampling strategy (Figure 3.3.8). It uses a systematic method to reveal fertility patterns and assumes there is no topographic reason for fertility patterns to vary within a field.

For grid sampling, a field is divided into small areas or blocks. A sample location within each block (e.g., the center point) is sampled 3 to 10 times. Sampling frequency may range from one sample from each 60 m × 60 m (0.5 ac) area of the field to one sample from each 2 ha (5 ac) of the field. In general, the smaller the sampling unit, the greater the accuracy.

### tip



Experience from the United States indicates that a sampling density of one bulk sample per acre is required to provide accurate information for variable rate fertilization. Sampling larger areas may still provide useful information about the extent of field variability.



tip



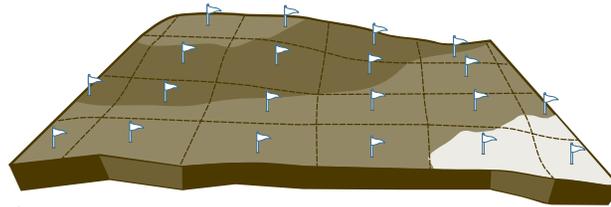
**Prior to soil sampling, contact the soil testing laboratory for more information regarding handling and shipping soil samples. In many cases, the lab will provide collection containers and/or shipping bags along with forms requesting information on cropping and management history of the sampled field. This information is used with test results to develop fertilizer recommendations. Some labs offer reduced rates for large numbers of samples or may pay the shipping costs.**

more info



**For more information on soil analysis requirements and other requirements under AOPA, search Ropin' the Web (keyword: AOPA), or contact the Publications Office in Edmonton (1-800-292-5697).**

The major benefit of grid sampling is that a field map can be prepared for each nutrient which can facilitate variable rate fertilizer application. However, the cost of analyzing the required number of samples makes this technique uneconomical for many producers.

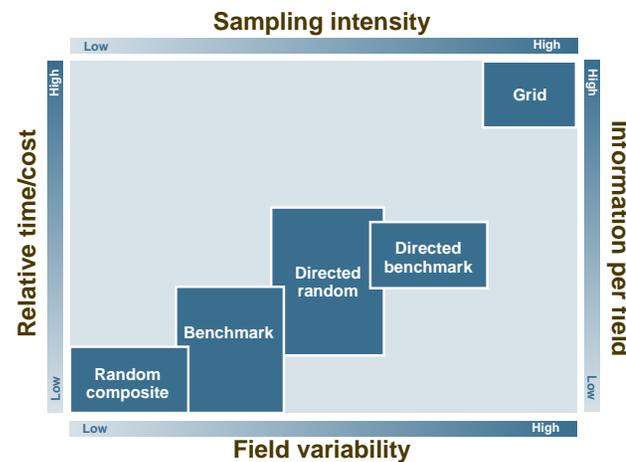


🚩 = Probe sites

Figure 3.3.8 Grid Sampling Pattern

Selecting the Appropriate Soil Sampling Strategy

The suitability of various sampling strategies is based on field variability or sampling intensity, relative cost and the amount of information desired (Figure 3.3.9).



Source: Kryzanowski, 2007

Figure 3.3.9 Suitability of the Various Sampling Strategies

Soil Sampling and AOPA

Under AOPA, confined feeding operations (CFOs) in Alberta that apply less than 500 tonnes (550 tons) of manure, compost or composting materials annually are exempt from the required soil analysis prior to land application. However, producers applying more than this amount require a soil analysis for fields scheduled to receive the material. For these fields, a test no older than three years is required (with the exception of soil texture, which is a one-time analysis) and must include:

- Extractable nitrate nitrogen (NO<sub>3</sub>-N) in the 0 to 60 cm (0 to 24 in) depth.
- Electrical conductivity (EC) in the 0 to 15 cm (0 to 6 in) depth.

Handling and Shipping Soil Samples for Analysis

Proper handling of soil samples prior to analysis will help ensure reliable test results. This section will describe proper handling techniques for moist samples, drying samples before shipping, and shipping samples.

Handling Moist Samples

If possible, moist samples should be delivered to the laboratory on the day they are collected. If this is not possible, samples can be refrigerated for a couple of days or frozen for a longer period. Refrigerating or freezing the samples stops microbial activity. This activity could result in nutrient transformations and affect the results of the analysis. Ensure moist samples spend no more than two days in transit.

## Drying Samples Prior to Shipping

If samples cannot be sent to the laboratory immediately, they can be air dried by:

- Spreading out each soil sample on a clean surface (aluminum pans, plastic trays, etc.).
- Allow the sample to completely air dry at a temperature no more than 30°C. If desired, a fan may be used to ensure constant airflow over samples to enhance drying. Do not dry in an oven, microwave or at a high temperature. This can change the levels of some nutrients, invalidating test results, and fertilizer recommendations.

## Shipping Samples

When shipping samples to the soil testing laboratory:

- Fill the soil sample bags or cartons with 0.5 kg (1 lb) of soil.
- Label each container with the information specified by the testing facility including: date of sampling, field number, contact name and sample depth.
- Complete an information sheet on cropping and fertilizer history. Note in detail where unusual problems exist.
- Ensure that samples do not become contaminated with anything that might invalidate test results (e.g., fertilizer).

## Laboratory Analyses

Consult the soil testing laboratory regarding available analysis packages. Typical soil analyses packages for surface (0 to 15 or 0 to 30 cm) agricultural soils should include soil analyses for:

- extractable nitrate nitrogen
- available P
- available K

- extractable sulphate sulphur
- soil pH
- salinity (electrical conductivity)

Nitrate and sulphate analysis should be completed for subsurface soil samples (15 to 30 and 30 to 60 cm). If high levels of NO<sub>3</sub>-N or available P are suspected, ask the lab to dilute the extract to get exact NO<sub>3</sub><sup>-</sup> and available P levels.

Additional analyses can also be requested for:

- micronutrients (boron, chloride, copper, iron, manganese or zinc)
- organic matter
- texture (usually a one-time analysis)

## Information to Submit with Samples

Soil samples should always be accompanied by information about the site, cropping expectations and management. This will put soil analysis results in context and lead to relevant fertility recommendations. Some of the information that should be submitted includes:

- **Legal land description or location:** This information is used to make assumptions about precipitation, soil zone, organic matter content, and length of the growing season. It can also be used to identify samples sent for analysis and for field records.
- **Planned crop rotation:** Planned rotation is used to determine fertility and nutrient requirements, which should be based on provincial yield response curves. The planned crop rotation will have implications for nutrient management due to differences in crop nutrient demand. Fertility recommendations based on test results can be developed for several different crops. Economics can then be factored into decision-making based on recommendations.

## tip



Use a reputable soil testing laboratory that uses Alberta

**data to determine fertilizer recommendations. Keep a copy of sample information sheets and a completed field plan of the area represented by each sample. Follow the packing and shipping instructions provided by the lab.**



## sidebar

**Information sheets, soil sample cartons, and shipping boxes are available from soil testing laboratories.**

### tip



**Realistic yield goals may be estimated from historical yields, seed**

**providers, regional variety trials, provincial averages, agronomists or service providers, specialists at the Ag-Info Centre, county offices or regional applied research associations.**



- **Realistic yield goals:** A realistic yield goal is one that is achievable for a crop grown in a given area under a particular management system. Yield goals must take into consideration previous year's crop, current and predicted moisture conditions, crop varieties, and time of year.
- **Previous crop:** This is particularly important if the previous crop was a legume or if the field was fallowed. Soil available N levels after fallow are generally higher and should be reflected in the soil analysis results. Legume residues will also provide N to subsequent crops; however, this N will not be detected in a standard soil analysis but will factor into fertility recommendations made by the lab.
- **Irrigated versus non-irrigated land:** Productivity (i.e., potential yield) and fertility recommendations will be higher for irrigated crops.
- **Residue management:** Crop residues have implications for nutrient availability to subsequent crops. Cereal and oilseed residues will immobilize nutrients reducing availability for the immediate needs of subsequent crops. Fertilizer recommendations are lower when straw is baled and removed than when it is spread.
- **Manure and fertilizer application history:** When making fertility recommendations, labs will consider previous nutrient applications (type or rates). When soil samples are taken immediately following manure or fertilizer application, some nutrients (e.g.,  $\text{NH}_4^+$ ) will not show up in standard soil analysis results. Likewise, organic nutrients from previous manure applications will become available gradually during the growing season and will not be reflected in test results. Without the nutrient application history, fertility recommendations may be inflated.
- **Moisture conditions:** Yield response is closely tied to moisture conditions. By reporting this information to the lab, fertility recommendations will be adjusted accordingly.

## summary

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- Soil sampling for nutrient management purposes should occur immediately before **seeding, just prior to active growth or in the fall** after soil temperatures drop below 5 to 7 °C.
- Sampling strategies include random sampling, directed random sampling, benchmark sampling, directed benchmark sampling and grid sampling. Benchmark sampling is the recommended sampling method for most situations, while **grid sampling is the most intensive.**
- **To accurately assess nutrient levels, samples** should be collected from the 0 to 15 cm, 15 to 30 cm and 30 to 60 cm soil depths.
- For best management, samples should be collected and analyzed annually. **AOPA regulations require that all fields receiving manure must have a soil analysis that is not older than three years.**
- Make sure samples are handled appropriately based on laboratory guidelines to ensure reliable test results. Moist samples should be kept cool and sent to the lab immediately. Samples that cannot be immediately shipped should be dried or frozen.
- Recommended analyses for samples include tests for: **extractable  $\text{NO}_3^-$ , available P, available K, extractable  $\text{SO}_4^{2-}$ , pH and salinity (electrical conductivity).**
- Soil samples submitted for analysis should be accompanied by information regarding legal land location, a realistic yield goal, production and management system information, and prior manure or fertilizer application history.